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Editorial – Volume 23 Issue 4

Dietmar Kennepohl
Associate Editor

Welcome to the final issue of the year.

The last two years have seen an unprecedented worldwide scramble and experimentation with alternative approaches to formal schooling and higher education. Consequently, IRRODL has been including articles reflecting the educational community's response to the pandemic. The fallout from the COVID-19 disruption, as well as how this will influence future approaches to teaching, are certainly on the collective conscious of educators everywhere.

It is therefore no surprise that we open this issue with *Impact of COVID-19 on Formal Education: An International Review of Practices and Potentials of Open Education at a Distance* from a global group of almost 20 authors (**Stracke**, **Sharma**, **Bozkurt**, et al.) that highlights and analyzes practices and case studies from 13 countries providing insights on effective and innovative strategies.

Innab, **Albloushi**, **Alruwaili**, **Alqahtani**, **Alenazi**, and **Alkathiri** in their COVID-19 related paper *The Influence of Sense of Community and Satisfaction With E-Learning and Their Impact on Nursing Students' Academic Achievement* underscore the importance of student-student interaction and engagement in providing quality online programs.

Ullah, **Khandakar**, **Aziz**, and **Kee**, in their paper *Technology Enabling the New Normal: How Students Respond to Classes* extend the technology acceptance model (TAM) and the theory of planned behavior (TPB) to depict the factors influencing undergraduate students' intention to attend online university classes during the COVID-19 pandemic.

Then to better inform future approaches, **Mavroudi** and **Papanikolaou** compare and contrast the experiences of tutors teaching in a distance education university with those who were teaching in a traditional university during lockdown in their article *A Case Study on How Distance Education May Inform Post-Pandemic University Teaching*. The study is intended to shape faculty development programs at traditional universities helping tutors support dialogical forms of online pedagogy.

In *Development of the Online Course Overload Indicator and the Student Mental Fatigue Survey* **Bayne** and **Inan** develop and validate survey instruments specific to the online learner. The aim is to reveal elements that may lead to students being overtaxed in an online learning environment.

In an effort to understand and eventually foster better online discourse, **Lemay**, **Doleck**, and **Brinton** propose in their article, *SLOAN: Social Learning Optimization Analysis of Networks,* a method for comparative analysis based on network metrics as more holistic measures characterizing social learning group dynamics.

Khor and **Dave** in their article, *A Learning Analytics Approach Using Social Network Analysis and Binary Classifiers on Virtual Resource Interactions for Learner Performance Prediction*, offer a framework for visualising learners' online behaviour and use the data obtained to predict whether the learners would complete a course.

In their quantitative study, *Open Distance and e-Learning: Ethiopian Doctoral Students' Satisfaction with Support Services*, **Aberra** and **Davids** assess and report on students' level of satisfaction with the quality of student support services provided by an open distance e-learning university.

The Community of Inquiry framework has been used to analyze the effectiveness of online education and hybrid education. In their study on *Translating and Validating the Community of Inquiry Survey Instrument in Brazil,* **Parulla**, **Weissheimer**, **Santos**, and **Cogo** facilitate its increased use in the Brazilian context and thus extending opportunities for comparisons with different educational realities.

We are presented with three *Book Reviews* in this issue. In the first review **Paskevicius** examines *An Introduction to Open Education* edited by Arts, Call, Cavan, Holmes, Rogers, Tuiloma, West, & Kimmons. This book provides a brief introduction to the topic of open education and was created as part of a graduate class project at Brigham Young University. The second review, *The Finest Blend: Graduate Education in Canada* edited by Parchoma, Power, and Lock is reviewed by **Marifah**. It presents case studies of universities across Canada that are experimenting with blended learning models in graduate programs. **Singh** provides the third review of *The Distributed University for Sustainable Higher Education* by Richard Heller. The book looks at problems facing universities in contemporary times and suggests how a "Distributed University" can reduce local and global inequalities in access.

In our *Literature Review* section **Zhang**, **Che**, **Nan**, and **Kim** provide us with a comprehensive survey of the development and evolution of MOOC research covering over 4,500 articles in the last decade. *MOOCs as a Research Agenda: Changes Over Time* allows the reader to better visualize collective advances historically and proposes novel ideas for future studies.

Finally in our *Notes* section, **Rawson**, **Okere**, and **Tooth** in *Using Low-immersive Virtual Reality in Online Learning: Field Notes from Environmental Management Education* explore the role of low-immersive VR as a desktop tool for online distance learning students.

There is plenty of good material in this issue to help one reflect on the response to the pandemic and how future educational approaches might evolve. Online and distributed learning will no doubt be an important part of that story—enjoy!

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Impact of COVID-19 on Formal Education: An International Review of Practices and Potentials of Open Education at a Distance

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Abstract

In terms of scale, shock, and disenfranchisement, the disruption to formal education arising from COVID-19 has been unprecedented. Anecdotally, responses from teachers and educators around the world range from heightened caution to being inspired by distance education as the "new normal." Of all the challenges, face-to-face and formal teaching have been most heavily affected. Despite some education systems demonstrating resilience, a major challenge is sustaining quality and inclusiveness in formal education suddenly delivered at a distance. In probing these issues, this article profiles international perspectives on the role of open education in responding to the impact on formal school and higher education caused by the COVID-19 pandemic. We proceed by highlighting and analysing practices and case studies from 13 countries representing all global regions, identifying and discussing the challenges and opportunities that have presented themselves. Reports cover the period from the beginning of 2020 until 11 March 2021, the first anniversary of the COVID-19 outbreak as declared by the World Health Organization. In our comparative study, we identify seven key aspects of which three (missing infrastructure and sharing OER, open education and access to OER, and urgent need for professional development and training for teachers) are directly related to open education at a distance. After comparing examples of existing practice, we make recommendations and offer insights into how open education strategies can lead to interventions that are effective and innovative—to improve formal education at a distance in schools and universities in the future.

Keywords: school education, higher education, distance education, online learning, open education, COVID-19 pandemic, impact, educational innovation, international practices and case studies, qualitative case study

Introduction

The current COVID-19 pandemic has shaken societies all around the globe. First reports about its impact on formal education were published by global organisations, such as the United Nations (2020), the Organization for Economic Co-operation and Development (OECD, 2021a, 2021b, Schleicher, 2020), and in particular the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2020, 2021), in collaboration with the United Nations Children's Fund, the World Bank, and OECD (UNESCO et al., 2020, 2021, UNICEF, 2020). They described how education systems in all countries witnessed severe disruptions and radical changes during varying degrees of lockdown. "Normal" (or traditional face-to-face) education was typically interrupted early on, once evidence emerged that younger carriers of the virus were more likely to be asymptomatic. This meant that new and adapted approaches and alternative delivery modes at a distance had to be designed and implemented without delay, sometimes bypassing established quality control processes. UNESCO implemented a platform (2021) to provide a global overview of all educational responses and resources connected to COVID-19. There are several studies (di Pietro et al., 2020; Popa, 2020) that collected and analysed educational practices and case studies from many countries responding to the COVID-19 challenges, but to our knowledge, the study by Bozkurt et al. (2020) is the first one addressing open education with special focus on distance learning in schools and universities.

The focus of this research was how open education was introduced and used for establishing and supporting distance learning in different regions worldwide during this period. Our key interest was the particular affordances of open education in the pandemic and what could be learned from the examples. Did the "online pivot" and a surge in distance delivery of education lead to more open approaches? Were there changes that are likely to remain beyond the ongoing pandemic? Through the analysis and comparison of regional case studies, we explored the strategies and practices that were developed and implemented and how much they were built on open education. In this way, we followed a broad approach to identify key aspects and build the ground for future research. We report on the first year of the pandemic from the beginning of 2020 until 11 March 2021, the first anniversary of the official COVID-19 outbreak as declared by the World Health Organization (WHO, 2020).

Terminology

Openness in education goes back to ancient times in Greece and beyond (Nerantzi, 2017; Robertson et al., 2020; Stracke, 2019). Etymologically, there exist strong connections with the Latin root term "liber," with semantics spanning freedom, open, and book. Open education is often directly connected with and understood as open access to education for all (Weller, 2020). However, it has been argued that such an understanding (reducing the concept to access issues) has shortcomings and that open education embraces much more: a philosophy of education and learning addressing and enabling openness at all educational levels and in all dimensions of formal and non-formal learning (Burgos, 2017; Inamorato dos Santos et al., 2016; Mason & Pillay, 2015; Naidu, 2019; Ossiannilsson et al., 2020; Stracke, 2017; Zawacki-Richter et al., 2020). The term open education could also be understood by placing emphasis on its qualifier "open," but even within the small group of open universities worldwide, there exists a large diversity in their institutional profiles, as well as in their understandings and practices of openness (Agbu et al., 2016).

In general and for the purposes of this paper, we use *open education* as an umbrella term under which different understandings are accommodated such as the eight different subtopics identified by Weller et al. (2018), the nine open dimensions identified by Stracke (2017), the 10 dimensions of open education as proposed by Inamorato dos Santos et al. (2016), the eight pillars by Burgos (2020), and the four practices of open education (Ramírez-Montoya, 2020). Such usage goes beyond open educational resources (OER) and open educational practices (OEP) including open courses and communities to embrace strategic decisions, teaching methods, collaboration between individuals and institutions, recognition of non-formal learning, and different ways of making learning and teaching materials available (Burgos, 2020; Inamorato dos Santos et al., 2016; Mason & Pillay, 2015; Ossiannilsson et al., 2020; Ramírez-Montoya, 2020; Stracke, 2019; Weller et al., 2018). In this sense, open education can be characterized as a holistic, open-minded approach, constantly reflecting all aspects of an educational ecosystem, such as learning objectives, needs, and practices to achieve quality education for all, and to sustain such approaches (Stracke, 2017). Thus, we broadly define open education adapting former definitions (Stracke, 2019; Zawacki-Richter et al., 2020) here:

> *Open education enables learning for all through facilitating openness on all educational levels (micro, meso, and macro) and in all dimensions (visionary, operational, and legal openness).*

To achieve that, teachers (used here in the broadest sense, including all educators), institutions, and education systems will face challenges delivering optimal learning opportunities. Such an objective does not have one single tradition that fits all, and it requires continuous adaptations and improvements that will very much depend on local contexts (Stracke, 2019).

As we consider the potential benefits for students in schools and universities, we need to ask many questions about open education: why, what, who, for whom, when, and how. Open education practitioners have not only to address economic inequities (access to resources), but also cultural (diversity, cultural sensitivity, and political voice and empowerment) dimensions of social justice. Otherwise, we risk reproducing the inequities we wish to change (Hodgkinson-Williams & Trotter, 2018).

Within the evolving nature of open education and its plurality of definitions is a core objective of enabling educational access to those who are disadvantaged or less likely to benefit from traditional education (Stracke et al., 2021; 2022). To facilitate access, open education can gain inspiration and support from other open initiatives such as open science to handle the sudden shift to distance and online education (Stracke, 2020). In the following sections, we analyse how formal education at a distance has been enabled during the COVID-19 pandemic by openness and practices, with specific focus on schools and universities (Burgos, 2020; Heck et al., 2020; Stracke et al., 2021; Weller, 2020).

Method

Open is a relative term with many different meanings and interpretations as explained in the introduction. We wanted to choose a methodology to accommodate and analyse this variety. Thus, we opted for a qualitative comparative case study with a broad international perspective collecting practices and case studies from 13 countries: Australia, Brazil, France, India, Mexico, the Netherlands, Nigeria, South Korea, Spain, Sweden, Taiwan, Turkey, and the United Kingdom. The practices and case studies describe how formal education was affected by the COVID-19 outbreak and replaced by distance learning. We analysed which strategies were developed and implemented and which good practices, lessons learned, and recommendations could be carried into the future. We focused on this central research question related to distance and online learning:

> *In what ways has open education been proposed and addressed using distance and online learning during the COVID-19 pandemic and lockdowns?*

The central question was formulated by the co-authors via consensus to enable regional reports reflecting the diversity of situations in relation to learning traditions, theories, support, and practices, as well as to given conditions and contexts such as education systems, curricula, assessments, institutions, resources, infrastructures, and laws.

A qualitative case study approach was adopted as it was seen as effective in documenting and describing diverse cases and contexts (Yin, 1984). The study also benefited from collective case study design which facilitates comparison and contrast across a set of cases (Stake, 1995). The authors—all experts in open and distance learning and education in a general sense—collected and reported the practices and case studies in order to synthesise them into an international perspective. Their analysis and comparison followed the three impact levels (macro, meso, and micro) in education (Stracke, 2019).

Contributions came from multiple authors, each representing certain territories across the continents. This approach enabled researchers to collect data from the real contexts and understand how open education is practised (Creswell & Plano Clark, 2018). Such a strategy enables and empowers researchers to discover how the research phenomenon is perceived and interpreted across the globe (Yin, 2011). On this basis, the primary data collection tools are observations of the researchers and documentary evidence that address the scope of the research questions (Yin, 1984).

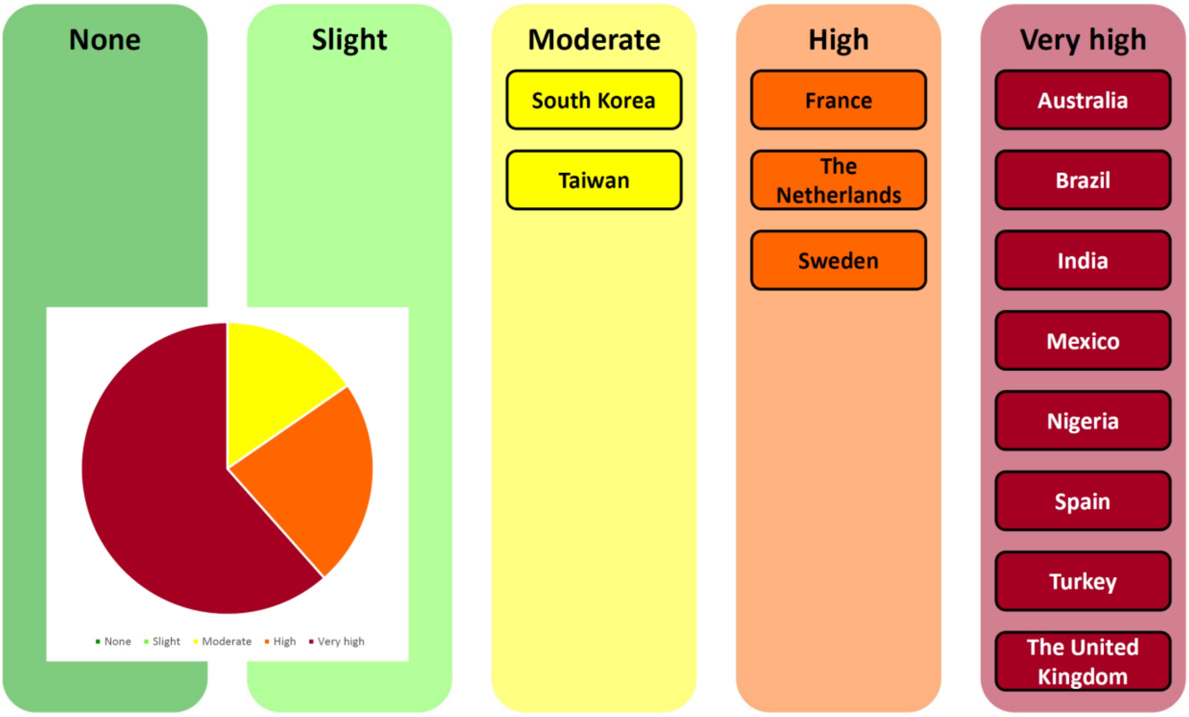
Using a collective approach to better understand research phenomena has some strengths and limitations. First, the approach uses researcher triangulation (Denzin, 1978) to frame research questions which further increases the reliability and validity of the research (Creswell, 2012; Oppermann, 2000). In this sense, it can be claimed that the strength of the research is its ability to provide a pluralistic view. Besides, researchers' experience in the field and on research topics can be regarded as another factor that contributes to the credibility of the study, notwithstanding that researchers' interpretations can be subjective and can reflect their own worldview to some extent (Creswell & Plano Clark, 2018). In our study, researchers were reminded that while a representative, pluralistic view is granted, open is a relative term with diverse meanings and interpretations in different demographic, socioeconomic, cultural, and political contexts as explained above.

Results

This section provides short overviews of the practices and case studies from the 13 countries. All the countries and their formal education were affected by the COVID-19 outbreak but with different intensities as presented in Figure 1.

Figure 1

Impact of COVID-19 on Formal Education in 13 Countries



In the following, we summarise the results focusing on our central research question. Findings are grouped in main central topics relevant for several countries, starting with the two major issues with high impact: students' marginalisation and missing pedagogical guidelines.

Marginalised or Excluded Student Groups

The COVID-19 outbreak and pandemic has severely impacted disadvantaged and marginalised social groups from lower socioeconomic backgrounds with less income and resources in general. Such students, and in many developing countries school-age children who cannot even claim the status of being a student, often lacked appropriate infrastructure or connectivity for communication with teachers and peers as well as support through their parents, impeding in particular students with special needs and lower socioeconomic backgrounds.

These negative effects were recognised early in Australian formal education through establishment of a website dedicated to resources addressing equity (National Centre for Student Equity in Higher Education, 2021). Turkey witnessed a clear case of digital divide, and digital literacies of teachers and students were differential. The government of Sweden put in place an enormous economic initiative and support measures for marginalised or excluded student groups to help them adapt to the situation, but also to sustain quality, health (even social-emotional health), and well-being. Other countries followed the Swedish example. However, increased stress and anxiety among teachers and students, increased workload, and negative effects on health were reported in several countries due to the transition to distance education mode. Students felt a sense of loneliness and isolation, and missed their social student life. In France, teachers and students comfortable with digital teaching and learning were in a better position than in other countries. Only around 2% of French students faced a digital gap resulting from stress managing personal work and attending classes in an unstable digital environment.

Missing, Restrictive, or Unrealistic Pedagogical Guidelines

In most countries, the implementation of open education and related practices resulted in the continuity of education, mainly in the distance delivery mode. However, specific guidelines for the implementation of distance learning were often lacking or too restrictive or unrealistic.

Positive examples can be found in Taiwan and Nigeria. The government of Taiwan provided good practice guidelines for online teaching covering course information, content, and activities. Adoption of OER in Taiwan was noted during the pandemic; however, teachers lacked suitable competences to integrate and apply OER in their teaching, and they felt and expressed an urgent need for training about it. In Nigeria, the National Open University of Nigeria (NOUN) and the 16 dual-mode institutions promoted open education with enthusiasm. In most other countries, there were issues in the mode of delivery and lack of related pedagogical guidelines. In Turkey, for example, imitating face-to-face courses by teachers and the summative assessment system posed great challenges to the government in assessing around 28 million students. In November 2020, the government of Sweden gave secondary schools the power to transition to distance education, which helped in decongesting school premises and reducing the spread of infection, but without direct support. In France, lack of digital competences in general and digital pedagogical competences in particular was noticeable, calling for appropriate training. In some countries, constantly changing policy decisions switching back to face-to-face education in schools or again back to distance learning as well as the frequent discussions preceding each switch posed serious concerns among the teachers.

Communication Between Students and Teachers

Communication between students and teachers is a crucial aspect for successful learning in the digital era. It has become even more important during the COVID-19 pandemic due to mobility restrictions and lockdowns and closures of educational institutions. Such challenging limitations hinder normal communication mechanisms. Focusing on positivity, people, and emotions are not only important in higher education (Chatzidamianos & Nerantzi, 2020) but in particular in school education. In most countries, there was an issue of differential access to digital learning platforms (for overviews, see Ministerio de Universidades, n.d.). Therefore, the communication between teachers and students sometimes was low and realised in social media, apps, e-mails, or in the form of telephone calls, short messages, or sending videos on smartphones. In most countries, virtual learning environments (VLE) and online platforms such as Zoom, MS Teams, or Google Meet were predominantly used by schools and universities for connecting teachers with students. In most institutions, these VLE and platforms were neither available nor used before the COVID-19 pandemic, leading to sudden introductions without any instruction and training.

Social networking sites and instant messaging platforms and apps played a significant role in these conditions (no available VLE and platforms) in many countries. In Sweden, teachers and students in high schools and higher education moved to distance education and were connected using online and offline tools and digital resources. These tools, which were widely adopted even before COVID-19, scaled up and helped in increased sharing and cultural awareness while fostering innovations and creativity. National websites and communication channels were launched in Australia, the Netherlands, Sweden, and Spain to help people with information, resources, funding, infrastructure, etc. The Nigerian government put in place suitable policies and established 16 dual-mode institutions to strengthen open distance education in Nigeria, safeguarding for health crises and promoting online and blended teaching and learning. In Mexico, the Ministry of Public Education (SEP) used open television channels and the Internet for basic education for students, but without a training model, this strategy was not effective. In Brazil, the Ministry of Education reported in a study from April and May 2020 (Instituto Península, 2020) that out of 7,734 teachers, the vast majority (83%) felt unprepared to engage in distance education practices, and 43% indicated that the lack of continuous professional development was a key issue.

Learning Designs Developed and Used During COVID-19

In most countries involved in this study, the promotion or development of learning designs for distance education was supported by national ministries and organisations in school and higher education. The launch of the Digital Education Action Plan (European Commission, 2020) in mid-2020 augmented distance and online learning throughout Europe, catering to students at different levels of education. The Australian Council for Educational Research (ACER) published a comprehensive guide on remote learning, although it is notable that this well-regarded institution omitted discussion of OER (Cowden et al., 2020).

Self-organised learning communities of teachers on social media provided social, technical, and pedagogical support for learning designs in most countries, specifically in Turkey, the UK, and Sweden. In Spain, in alignment with open educational practices, the focus was put on educational personalisation and a new culture of teacher cooperation and coordination. The offered online courses promoted social and educational inclusion. The Australian Citizen Science Association (ACSA) enabled online learning for leveraging citizen science after the devastating wildfires in early 2020 as a notable example. In Taiwan, virtual reality (VR) solutions using 360 VR technology were adopted during the COVID-19 pandemic, allowing distance education and maintaining social distance. At the same time, street loudspeakers were used in some cities in India where there was no Internet; students sat in the streets and received instructions over public address systems. In France, open access and open science provided a great support to teachers and students: several national associations concerned about access to important documents (ICOLC, followed by ADBU, Couperin, and EPRIST) urged publishers to open their publications to meet the challenges of the COVID-19 crisis. Teachers published their lectures and contents online for school and university students on the platform *Cours en Ligne*. In Nigeria, UNESCO partnered with NUC and NOUN. They conducted, in March 2021, a workshop on distance learning designs focusing on developing and implementing OER. In the UK, digital access to materials was enabled as a national initiative which could have boosted OER movement; however, it was more of an act of charity and support (JISC, 2020). Another challenge arose when commercial providers began taking advantage of the pandemic by price gouging (Fazackerley, 2021).

Platforms and Innovative Pedagogies Facilitating Open Education at a Distance

While enormously challenging, the COVID-19 pandemic has also created an opportunity in education systems for a paradigm transition towards openness as well as for distance or digitally-supported learning. In most countries, the national ministries and authorities established online platforms for teachers to facilitate open education at a distance, but only some provided guidelines for appropriate innovative pedagogies. With the purpose of bridging the digital divide, an Education Open Data Challenge was launched by the global Open Data Institute (ODI) in partnership with Microsoft to promote innovative solutions for open education (ODI, 2020).

South Korea has committed to implementing open education at a distance for innovating pedagogies as a result of the COVID-19 pandemic. That is currently under discussion at a national level and will take some time to be legislated (Kalezi et al., 2020). In Taiwan, open education at a distance has been supported by the popular Taiwan Open Course and Education Consortium (TOCEC) as well as by the government for many years. For example, Taiwan has offered more than 1,400 massive open online courses (MOOCs) to promote open content or open educational practice, with the notable feature that these MOOCs are aligned with national quality standards. In India, two platforms, SWAYAM (Study Webs of Active–Learning for Young Aspiring Minds), which is a MOOC, and SWAYAM PRABHA (a bundle of 34 satellite TV channels broadcasting high-quality educational programmes into households on 24x7 basis), were made available to students. In Australia, open education at a distance is less evenly adopted, while science publishing opened up during the COVID-19 pandemic which would normally not be easy to sustain. The Dutch Ministry of Education supported a news group on online education for all Dutch teachers and scientists in higher education. In Mexico and Spain, institutions with distance learning capabilities put in place training and communication strategies and used open platforms, repositories, and materials for design and delivery of courses, while the institutions without such distance learning experiences faced challenges in communications among teachers and students (Rodríguez-Abitia et al., 2020; Santos-Hermosa et al., 2020).

Sharing and Implementing OER for Open Education

The UNESCO recommendation on OER (2019) highlighted their benefits and established annual OER reporting from all UNESCO member states. One major immediate action in almost all countries was the promotion of OER and their use in designing and implementing open education in both face-to-face and distance modes.

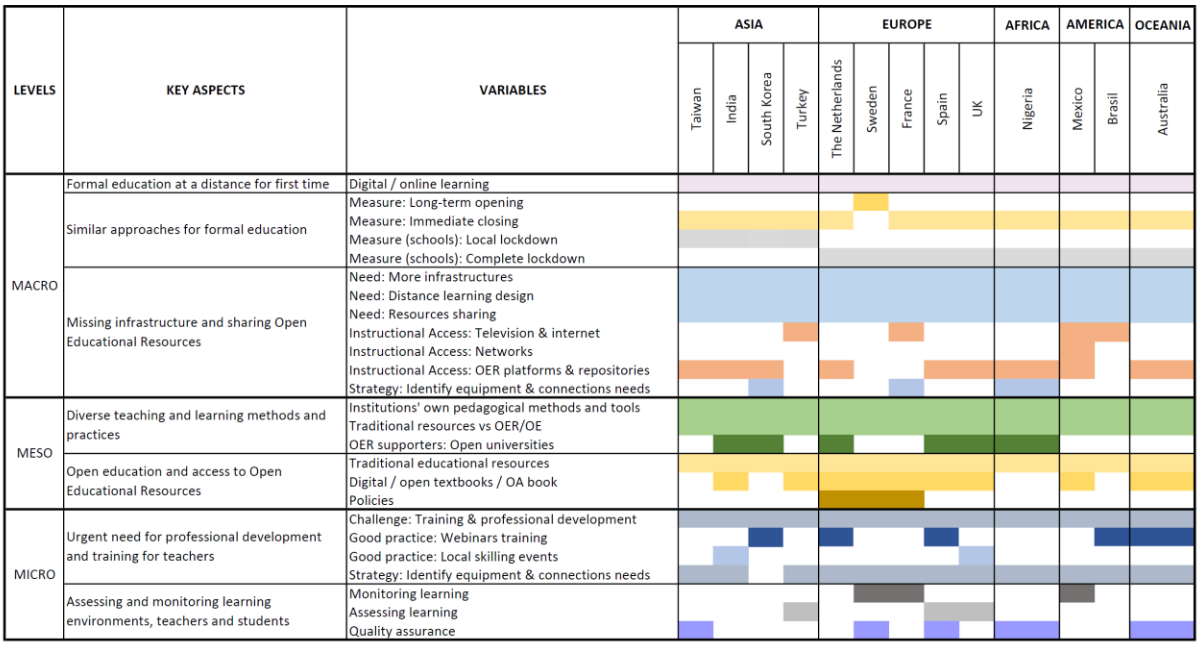
In Turkey, open education and OER were extensively practiced and used; however, the critical components of open education (e.g., open licences, pedagogical frameworks, and models) were ignored. This lack of awareness about the use of OER may be viewed in terms of an anonymised way of the cultural interpretation of sharing resources. In Spain, MOOCs and OER were developed and shared on many platforms (some developed due to the COVID-19 pandemic), including UNIRTv, a video portal hosted by Universidad Internacional de la Rioja with over 500,000 lectures, conferences, and webinars, mainly in Spanish and English. Furthermore, the European Commission (2021) established a European platform for collecting and sharing learning resources during the COVID-19 pandemic. In India, the DIKSHA (Digital Infrastructure for Knowledge Sharing) platform of the government has a mandate of competence development for teachers and provides access to curriculum-linked OER such as e-content, quizzes, and QR-coded energised textbooks (Phygital Textbooks). In addition, the National Repository of OER (NROER) is an open storehouse of e-content in various languages and formats. In Brazil, the Ministry of Education created the OER portal MEC-RED and reinforced the National Programme for Textbooks (PNLD–Programa Nacional do Livro Didático) to ensure that all textbooks have an open licence and will continue to be offered for free to the 32 million students and 127,000 schools of the public basic education system in Brazil.

Discussion and Limitations

This section discusses key aspects of the complete reported practices and case studies from the 13 countries. Various national, regional, and local solutions were implemented, taking into account the new laws and specific regulations that emerged in the different countries and regions facing COVID-19. We compared these 13 case studies, clustering and synthesising key aspects valid for most (and sometimes all) countries, structured according to the three generic impact levels (macro, meso, and micro) in education (Stracke, 2019). Figure 2 presents the results of our comparison.

Figure 2

Impact of COVID-19 on Formal Education in 13 Countries



Note: The colours are arbitrarily selected indicating only which variables are connected.

In total, we identified seven key aspects answering our research question concerning how, during the COVID-19 pandemic, formal education at a distance was introduced and realised in schools and universities and how open education supported it. Table 1 shows these seven key aspects. Three are related to open education, and we concentrate our discussion on them.

Table 1

Key Aspects of Distance Education Due to COVID-19 in 13 Countries

Level	Key Aspect
Macro	Formal education at a distance for first time
	Similar approaches for formal education
	Missing infrastructure and sharing OER
Meso	Diverse teaching and learning methods and practices
	Open education and access to OER
Micro	*Urgent need for professional development and training for teachers*
	Assessing and monitoring learning environments, teachers, and students

Note. Aspects related to open education are shown in italics.

Missing Infrastructure and Sharing OER

At the macro level, missing infrastructure and experiences of distance education challenged mainly formal education in most countries. In all countries, designing distance learning paths and sharing digital (open) educational resources became a priority. The schools and universities that had established an infrastructure for open education at a distance before the COVID-19 outbreak and that could rely on teachers with related competences and resources managed the challenges of distance learning more smoothly. Peer support among teachers and institutions strengthened a culture of sharing resources and experiences.

In order to provide easy and free access to online and broadcast educational resources, several national solutions relied on television and the Internet, as they are mainstream media channels, and sometimes used networks (Turkey, France, Mexico, and UK). In India, SWAYAM PRABHA, broadcasting high-quality educational programmes via satellite, reached all regions of the vast country including the parts without Internet and mobile connectivity. In some countries, private companies and EdTechs partnered to design educational workspaces and provide access to educational resources. Many teachers chose to share their resources (short lessons, exercises, etc.), created during the period of lockdown, very often through direct and personal channels of communication on the Internet and social messaging platforms. Many teachers and students have also been very resourceful and inventive with the limited resources available. The modes and strategies for instructional delivery have diversified: OER produced in various countries have been used by teachers, students, and their parents and carers. The period has increased awareness of the internationalisation and mutualisation of educational resources. Sharing OER sometimes led to or accelerated developing open education solutions and platforms such as BELUGA in Africa. In India, the national platform DIKSHA provided distance learning paths and OER for school education supporting millions of teachers and students. Another strategy considered how to identify and remedy the need for equipment and connections in individual households, and how to reach disadvantaged geographical areas or vulnerable populations (France, Nigeria, South Korea, and Sweden). Higher education students were particularly considered by national, local, or institution-related initiatives because in almost all countries, universities were indefinitely closed and only distance education could be offered.

Open Education and Access to OER

At the meso level, innovative pedagogies and practices for enabling open education at a distance were reported mainly in combination with demands for access to OER. In general, access to resources is closely linked to educational practices, whether it concerns learning materials and documentation to be read by students or useful resources for teachers to enrich and develop their practices. In school and higher education, a strong persistence of traditional resources such as books and manuals was noted: institutions mainly focused on tools and workspaces for distance education, but did not explore much the possibilities offered by digital OER and innovative open education. Negotiation for granting access to e-published books and journals was a current action by ministries, education councils, and academic library consortia, supported by national and international calls to publishers, with a particular focus on health-related disciplines. Next to academia and publishing communities, teachers also identified the need for OER to design and deliver distance learning with the claim of innovative open education and pedagogies. Furthermore, we noted that policies and strategies to help introduce openness in education systems were developed by some institutions in countries such as the Netherlands, Sweden, and Taiwan, while other countries began to follow their examples (India, Mexico, Nigeria, South Korea, and Spain).

Urgent Need for Professional Development and Training for Teachers

At the micro level, the biggest challenge during the COVID-19 pandemic lay in capacity building and competence development for teachers as well as for support staff, either in a group or individually. Distance teaching revealed strong differences related to technology abilities and the pedagogical and digital competences required for distance learning that were a professional development and training challenge. These different (and often missing) abilities and competences of teachers and support staff to design and implement appropriate distance education and pedagogical approaches and to use existing tools or adapt to new environments, sometimes inadequate or insufficient, led to often complicated solutions, calling for stronger, agile, brave, and resilient leadership and infrastructure. Experimental approaches by enthusiastic teachers coexisted with strong resistance, mainly in schools, while in universities, the culture of experimentation, sharing, peer learning, and communities of practice developed more radically due to the announced and long-term lockdowns in higher education. Some countries were able to provide training and support, sometimes thanks to years or decades of experience in distance learning systems (India, South Korea, and Sweden), but very large inequalities appeared since this massive shift towards online activity often occurred without preparation.

Limitations of This International Review

There are several limitations of this international review. First, the practices and case studies reported here were based on convenience and direct access to experts who had availability to participate in this study. Second, the subjective nature of the cases and their collections are based on individual knowledge and overviews. Third, drawing international conclusions from a limited data set is challenging for generalisations. Fourth, drawing conclusions across diverse cases leads to comparisons of diverse circumstances and contexts without consideration of huge differences in traditions, context, conditions, and cultures. Importantly, we have not specifically addressed the alarming numbers of out-of-school children that now exist at a scale unimagined prior to the pandemic (Badar & Mason, 2020). This is partly a consequence of our focus on formal education. Finally, as already mentioned above, we cannot judge, value, or validate the different strategies and practices taken in the countries but only categorise them for a first overview.

For a deeper understanding and truly global perspective and analysis, we need broader and longitudinal research to collect, compare, and evaluate all challenges, experiences, and solutions that were made with open education and distance learning during the COVID-19 pandemic.

Consequently, this comparative case study and its results are only the basis for further research. It is important to emphasise that the identified practices of open education at a distance can be reproduced and, in particular, be improved in similar contexts and in the future.

Conclusion

The COVID-19 pandemic has disrupted education globally, to which the education sector has responded with a range of pedagogical ideas and innovations, practices, and strategies. School and higher education have changed dramatically in a short time, implementing distance learning in many cases for the first time as a new normal and both benefitting and facilitating open education.

Our analysed international practices and case studies of the use or lack of use of open education and OER during the COVID-19 pandemic highlight economic inequities (access to infrastructure and resources), cultural injustice (lack of cultural sensitivity), and political injustice where teachers in various constrained environments lack voice and empowerment.

This period also brought into focus a broadening digital divide, with huge numbers of students in low-income countries unable to participate in formal education. Examples from Taiwan, India, and Australia illustrate innovative socially responsible initiatives enabling students to access materials and information. In some regions, OER was an act of charity and support while in other places, formal education depended upon it. This further highlights the still prevailing ignorance about OER in some cases, while MOOCs again gained prominence, providing a good number of quality resources to students and teachers.

We noted diverse teaching and learning methods based upon infrastructure, tools, and trained or untrained teachers. This reveals the need for training teachers in digital competences including open pedagogies. It was expected that the adoption of open education and OER would accelerate and become standard in distance learning. However, as reported, traditional pedagogies and teaching models based on books and manuals persisted in many cases.

On the other hand, the COVID-19 pandemic has pushed teachers to collaborate to a greater extent and also increased teacher engagement with collaborative processes and network-based tools. The emergence of a culture of cooperation, collaboration, and coordination has been quite evident. This was necessary for inclusion at all levels institutionally, and with parents and students.

Open and clear communication and distributed, brave, and proactive leadership are vital during a time of a crisis, which has been true in particular during the COVID-19 lockdowns. Instructions about educational delivery modes and assessment by government bodies to the institutions set unique conditions. Teachers and students at schools and universities often experienced distance learning for the first time. For direct communication among students and teachers, but also with parents and carers, the use of instant messaging apps and social networking was handy. A wide range of offline, online, and digital tools were used. Some companies, organisations, and even individuals came forward to share tools, technology, and resources.

Pedagogy of care, compassion, and empathy was another phenomenon, as the pandemic induced trauma, emotional fatigue, and, in some cases, domestic violence. Student isolation was mitigated with regular online sessions and webinars. However, there have been reports (UNESCO et al., 2020, 2021) that these webinars became overused and that there was a sense of revolt among parents and students as screen time drastically increased. The major transition noted was the offering of formal education at a distance (spatial and temporal). However, it was primarily not synchronous distance education, but rather only the delivery of tasks for self-regulated learning. Due to the COVID-19 lockdowns, normal movement was restricted, and this gave rise to electronic communications using television, Internet, and even satellites, as in the case of India.

From a planning perspective, we noted that it was also the time for institutions to develop open policies and strategies of openness in education systems. Quality assurance, assessment, and monitoring, prime concerns during this time, were discovered and discussed but not completely addressed and resolved. The COVID-19 pandemic led to unpredicted experiences and spontaneous establishment of distance education as the new normal without adequate preparation. That has highlighted the need in formal education for developing digital competences and technologies together with designing innovative and appropriate pedagogical methodologies and services for distance education. Teachers, students, as well as parents and policy makers could gain unique experiences when tackling the lockdown through distance education.

Political injustice in the form of misrepresentation and an associated lack of voice of teachers and students needs to be addressed. This pandemic has highlighted the need for inclusion and amplified the call for social justice in education systems. Open movements, often grassroots driven by dedicated individuals as well as institutions, can make a difference and lead to paradigm shifts as reported. Open education could demonstrate its benefits for distance learning as the potential new normal through opening up formal distance education using innovative learning designs and pedagogies and creating and sharing OER.

Our comparative case study provides the basis and underlines the need for broad research agendas on open and distance learning. Additional studies can follow up using our provided structure and first insights, collecting more granular and structured data in all regions worldwide. Overall, future research should address all three educational levels and focus visionary, operational, and legal aspects, as well as social justice perspectives, including a pedagogy of care and empathy.

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References

Agbu, J. O., Mulder, F., De Vries, F., Tenebe, A., & Caine, A. (2016). The best of two open worlds at the National Open University of Nigeria. *Open Praxis, 8*(2), 111–121. https://doi.org/10.5944/openpraxis.8.2.279

Badar, F. B., & Mason, J. (2020). Numbers are alarming, solutions are scant—Out of school children in Pakistan. *The International Conference on Sustainable Development 2020 (ICSD2020)*. https://ic-sd.org/wp-content/uploads/2020/11/Faisal-Badar.pdf

Bozkurt, A., Jung, I., Xiao, J., Vladimirschi, V., Schuwer, R., Egorov, G., Lambert, S. R., Al-Freih, M., Pete, J., Olcott, Jr., D., Rodes, V., Aranciaga, I., Bali, M., Alvarez, Jr., A. V., Roberts, J., Pazurek, A., Raffaghelli, J. E., Panagiotou, N., de Coëtlogon, P., . . . Paskevicius, M. (2020). A global outlook to the interruption of education due to COVID-19 pandemic: Navigating in a time of uncertainty and crisis. *Asian Journal of Distance Education, 15*(1), 1–126. https://doi.org/10.5281/zenodo.3878572

Burgos, D. (Ed.) (2017). *Open education policy*. UNIR. http://bit.ly/unir-openpolicy

Burgos, D. (Ed.) (2020). *Radical solutions and open science. An open approach to boost higher education*. Springer. https://doi.org/10.1007/978-981-15-4276-3

Chatzidamianos, G., & Nerantzi, C. (2020, June 3). *Stripping the layers of the onion in learning and teaching in HE*. AdvanceHE. https://www.advance-he.ac.uk/news-and-views/stripping-layers-onion-learning-and-teaching-he

Cowden, G., Mitchell. P., & Taylor-Guy, P. (2020). *Remote learning. Rapid literature review*. Association of Independent Schools NSW & Australian Council for Educational Research. https://doi.org/10.37517/978-1-74286-610-9

Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Sage.

Creswell, J. W., & Plano Clark, V. L. P. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods and practice*. Sage.

di Pietro, G., Biagi, F., Costa, P., Karpinski, Z., & Mazza, J. (2020). *The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets*. Publications Office of the European Union. https://doi.org/10.2760/126686

European Commission. (2020). *Digital education action plan (2021-2027). Resetting education and training for the digital age*. https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en

European Commission. (2021). *Coronavirus: Online learning resources*. https://ec.europa.eu/education/resources-and-tools/coronavirus-online-learning-resources_en

Fazackerley, A. (2021, January 29). “Price gouging from Covid”: Student ebooks costing up to 500% more than in print. *The Guardian*. https://www.theguardian.com/education/2021/jan/29/price-gouging-from-covid-student-ebooks-costing-up-to-500-more-than-in-print

Heck, T., Kullmann, S., Hiebl, J., Schröder, N., Otto, D., & Sander, P. (2020). Designing open informational ecosystems on the concept of open educational resources. *Open Education Studies, 2*, 252–264. https://doi.org/10.1515/edu-2020-0130

Hodgkinson-Williams, C. A., & Trotter, H. (2018). A social justice framework for understanding open educational resources and practices in the global South. *Journal of Learning for Development*, *5*(3), 204–224. https://jl4d.org/index.php/ejl4d/article/view/312

Inamorato dos Santos, A., Punie, Y., & Castano Muniz, J. (2016). *Opening up education: A support framework for higher education institutions*. Publications Office of the European Union. https://www.doi.org/10.2791/293408

Instituto Península. (2020). *Sentimento e percepção dos professores brasileiros nos diferentes estágios do coronavírus no Brasil* [Feeling and reception of Brazilian educators at different stages of the corona virus in Brazil]. https://www.institutopeninsula.org.br/wp-content/uploads/2021/05/Diagrama%C3%A7%C3%A3o-Pulso.pdf

JISC. (2020, March 18). *Free student e-textbook programme to give university students and staff access to learning resources*. https://www.jisc.ac.uk/news/free-student-etextbook-programme-18-mar-2020

Kalezi, C., Back, D., & Yim, M. (2020, November 13). *The future of online education: Lessons from South Korea*. World Economic Forum. https://www.weforum.org/agenda/2020/11/lessons-from-south-korea-on-the-future-of-online-education

Mason, J., & Pillay, H. (2015). Opening digital learning to deeper inquiry. In M. Ally & B. H. Khan (Eds.), *The international handbook of e-learning* (Vol. 2, pp. 1–10). Routledge.

Ministerio de Universidades. (n.d.). *Informe de iniciativas y herramientas de evaluación online universitaria en el contexto del Covid-19* [Report on academic online evaluation initiatives and tools in the context of Covid-19]. http://www.feccoo-madrid.org/965dc797a0c3208f893b9a217b3ce1d5000063.pdf

Naidu, S. (2019). The changing narratives of open, flexible and online learning. *Distance Education, 40*(2), 149–152. https://doi.org/10.1080/01587919.2019.1612981

National Centre for Student Equity in Higher Education. (2021). *COVID-19—Resources for the higher education sector*. https://www.ncsehe.edu.au/practice/covid-19

Nerantzi, C. (2017). *Towards a framework for cross-boundary collaborative open learning in cross-institutional academic development* [Doctoral dissertation, Edinburgh Napier University]. https://www.napier.ac.uk/~/media/worktribe/output-1025583/towards-a-framework-for-cross-boundary-collaborative-open-learning-for.pdf

ODI. (2020, November 10). *Education open data challenge: The impact of digital access on education during Covid-19*. https://theodi.org/article/education-open-data-challenge-the-impact-of-digital-access-on-education-during-covid-19

OECD. (2021a, July 1). *The state of higher education. One year into the COVID pandemic*. https://doi.org/10.1787/83c41957-en

OECD. (2021b, April 13). *The state of school education. One year into the COVID pandemic*. https://doi.org/10.1787/201dde84-en

Oppermann, M. (2000). Triangulation - a methodological discussion. *International Journal of Tourism Research, 2*(2), 141–145. https://doi.org/10.1002/(SICI)1522-1970(200003/04)2:2<141::AID-JTR217>3.0.CO;2-U

Ossiannilsson, E., Zhang, X., Wetzler, J., Gusmão, C., Aydin, C. H., Jhangiani R., Glapa-Grossklag, J., Makoe, M., & Harichandan, D. (2020). From open educational resources to open educational practices. For resilient sustainable education. *Distances et Médiations des Savoirs, 31*. https://doi.org/10.4000/dms.5393

Popa, S. (2020). Reflections on COVID-19 and the future of education and learning. *Prospects, 49*(1), 1–6. https://doi.org/10.1007/s11125-020-09511-z

Ramírez-Montoya, M. S. (2020). Challenges for open education with educational innovation: A systematic literature review. *Sustainability, 12*(17), Article 7053. https://doi.org/10.3390/su12177053

Robertson, L. H., Robertson, D. T., & Robertson, T. J. (2020). The opened mind: An application of the historical concept of openness in education. In D. Conrad & P. Prinsloo (Eds.), *Open(ing) education theory and practice* (pp. 26–46). Brill Sense.

Rodríguez-Abitia, G., Martínez-Pérez, S., Ramirez-Montoya, M. S., & Lopez-Caudana, E. (2020). Digital gap in universities and challenges for quality education: A diagnostic study in Mexico and Spain. *Sustainability, 12*(21), Article 9069. https://doi.org/10.3390/su12219069

Santos-Hermosa, G., Estupinyà, E., Nonó-Rius, B., Paris-Folch, L., & Prats-Prat, J. (2020). Open educational resources (OER) in the Spanish universities. *Profesional De La Información, 29*(6), Article e290637. https://doi.org/10.3145/epi.2020.nov.37

Schleicher, A. (2020). *The impact of Covid-19 on education. Insights from Education at a Glance 2020*. OECD. https://www.oecd.org/education/the-impact-of-covid-19-on-education-insights-education-at-a-glance-2020.pdf

Stake, R. E. (1995). *The art of case study research: Perspective in practice*. Sage.

Stracke, C. M. (2017). The quality of MOOCs: How to improve the design of open education and online courses for learners? In P. Zaphiris & A. Ioannou (Eds.), *Learning and collaboration technologies. Novel learning ecosystems* (pp. 285–293). Springer. https://doi.org/10.1007/978-3-319-58509-3_23

Stracke, C. M. (2019). Quality frameworks and learning design for open education. *The International Review of Research in Open and Distributed Learning, 20*(2), 180–203. https://doi.org/10.19173/irrodl.v20i2.4213

Stracke, C. M. (2020). Open science and radical solutions for diversity, equity and quality in research: A literature review of different research schools, philosophies and frameworks and their potential impact on science and education. In D. Burgos (Ed.), *Radical solutions and open science: An open approach to boost higher education* (pp. 17–37). Springer. https://doi.org/10.1007/978-981-15-4276-3_2

Stracke, C. M., Burgos, D., Santos-Hermosa, G., Bozkurt, A., Sharma, R. C., Cassafieres C. S., Inamorato dos Santos, A., Mason, J., Ossiannilsson, E., Shon, J. G., Wan, M., Obiageli Agbu, J. F., Farrow, R. Karakaya, Ö., Nerantzi, C., Ramírez Montoya, M. S., Conole, G., Cox, G., & Truong, V. (2022). Responding to the initial challenge of the COVID-19 pandemic: Analysis of international responses and impact in school and higher education. *Sustainability, 14*(3), Article 1876. https://doi.org/10.3390/su14031876

Stracke, C. M., Sharma, R. C., Swiatek, C., Burgos, D., Bozkurt, A., Karakaya, Ö., Ossiannilsson, E., Mason, J., Nerantzi, C., Agbu, J.-F., Ramírez Montoya, M. S., Shon, J. G., Inamorato dos Santos, A., Farrow, R., Wan, M., Santos-Hermosa, G., & Conole, G. (2021). How COVID-19 has an impact on formal education: A collective international evaluation of open education in distance learning. In L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *Proceedings 14th Annual International Conference of Education, Research and Innovation* (pp. 4270–4275). IATED Academy. https://doi.org/10.5281/zenodo.5764585

UNESCO. (2019, November 25). *UNESCO Recommendation on open educational resources*. http://portal.unesco.org/en/ev.php-URL_ID=49556&URL_DO=DO_TOPIC&URL_SECTION=201.html

UNESCO. (2020, March 6). *COVID-19: 10 recommendations to plan distance learning solutions*. https://en.unesco.org/news/covid-19-10-recommendations-plan-distance-learning-solutions

UNESCO. (2021). *COVID-19 response*. https://en.unesco.org/covid19

UNESCO, UNICEF, & The World Bank. (2020, October). *What have we learnt?: Overview of findings from a survey of ministries of education on national responses to COVID-19*. http://tcg.uis.unesco.org/wp-content/uploads/sites/4/2020/10/National-Education-Responses-to-COVID-19-WEB-final_EN.pdf https://data.unicef.org/resources/national-education-responses-to-covid19

UNESCO, UNICEF, The World Bank, & OECD. (2021, June). *What's next? Lessons on education recovery: Findings from a survey of ministries of education amid the COVID-19 pandemic.*

http://covid19.uis.unesco.org/wp-content/uploads/sites/11/2021/07/National-Education-Responses-to-COVID-19-Report2_v3.pdf

UNICEF. (2020, October). *What have we learnt?: Findings from a survey of ministries of education on national responses to COVID-19*. https://data.unicef.org/resources/national-education-responses-to-covid19

United Nations. (2020, August). *Policy brief: Education during COVID-19 and beyond*. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/sg_policy_brief_covid-19_and_education_august_2020.pdf

Weller, M. (2020). Open and free access to education for all. In D. Burgos (Ed.), *Radical solutions and open science: An open approach to boost higher education* (pp. 1–15). Springer. https://doi.org/10.1007/978-981-15-4276-3_1

Weller, M., Jordan, K., DeVries, I., & Rolfe, V. (2018). Mapping the open education landscape: Citation network analysis of historical open and distance education research. *Open Praxis*, *10*(2), 109–126. https://doi.org/10.5944/openpraxis.10.2.822

WHO. (2020, March 11). *Coronavirus disease 2019 (COVID-19). Situation report – 51*. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10

Yin, R. K. (1984). *Case study research: Design and methods*. Sage.

Yin, R. K. (2011). *Qualitative research from start to finish*. Guilford Publications.

Zawacki-Richter, O., Conrad, D., Bozkurt, A., Aydin, C. H., Bedenlier, S., Jung, I., Stöter, J., Veletsianos, G., Blaschke, L. M., Bond, M., Broens, A., Bruhn, E., Dolch, C., Kalz, M., Kerres, M., Kondakci, Y., Marin, V., Mayrberger, K., Müskens, W., . . . & Xiao, J. J. (2020). Elements of open education: An invitation to future research. *The International Review of Research in Open and Distributed Learning, 21*(3), 319–334. https://doi.org/10.19173/irrodl.v21i3.4659

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The Influence of Sense of Community and Satisfaction With E-Learning and Their Impact on Nursing Students' Academic Achievement

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Abstract

The COVID-19 pandemic has caused a sudden shift to distance learning. For many nursing students, distance learning is a new experience and an essential requirement if they hope to complete their programs. Two challenges that nursing students could face during e-learning are the lack of social presence and low satisfaction. This study aimed to assess students' sense of community and satisfaction during e-learning and determine their impacts on academic achievement. This cross-sectional descriptive study used convenience sampling to collect data via a student satisfaction survey and a classroom community scale. There was a positive and significant correlation between the sense of community, total satisfaction with e-learning ($p < .001$), and academic achievement ($p < .001$). Academic achievement was positively and strongly correlated with satisfaction with teaching ($p < .001$), assessment ($p < .001$), generic skills and learning experiences ($p < .001$), and total satisfaction with e-learning ($p < .001$). Students who worked collaboratively with their classmates and were more engaged in their learning were more satisfied with e-learning and had higher academic achievement ($p < .01$). Female participants reported a strong sense of community and satisfaction with e-learning and greater academic achievement than males. Junior students perceived higher satisfaction scores and greater academic achievement ($p < .01$) than senior students. The findings of this study suggest that failing to meet student expectations can lead to low levels of student involvement. Students' engagement and satisfaction are good indicators of the quality and effectiveness of online programs.

Keywords: satisfaction, students, distance learning, sense of community, academic achievement, Saudi Arabia

Introduction

In most institutions, distance learning is not a novel mode of instruction. Yet, the spread of coronavirus disease beginning in 2019 (COVID-19) affected education systems globally (Murphy, 2020). Moreover, lockdowns during the ongoing pandemic affected health professionals' education and training. At the beginning of the pandemic, most courses went online to enforce social distancing among students and reduce transmission of the virus. Several programs conducted all their classes via distance learning using various online educational platforms to achieve learning outcomes and sustain the learning process. Distance learning was considered an effective strategy for delivering course content (Taylor et al., 2020).

The use of e-learning in higher education has increased rapidly in the last decade (Khalil et al., 2020). E-learning is a valuable method that allows students flexibility in their learning experiences and enables them to study at a time and location that is convenient. According to several studies, students consider e-learning simple to use (Opeyemi et al., 2019) and also comfortable and accessible due to readily available learning materials (Mukhtar et al., 2020).

Like other programs across the globe, the nursing programs in Saudi Arabia (SA) shifted to distance learning mode due to the rise in COVID-19 cases to help students complete required courses. The sudden shift to distance learning was a new experience for many nursing students (Bdair, 2021).

The effectiveness of e-learning is well documented in the literature. Numerous studies have highlighted the various benefits of online learning for students, including saving money and time spent on transportation and being able to spend more time with their families, study at their convenience, and sleep or rest more (Suliman et al., 2021; Tang et al., 2015). Students also discovered that online learning made them more independent in their learning, enhanced their critical thinking and problem-solving abilities, and encouraged self-reliance (Button et al., 2014; Sinaga et al., 2018; Suliman et al., 2021; Tang et al., 2015). However, there is a dearth of research assessing nursing students' sense of community and its impact on their satisfaction.

Background

Development of a sense of community is not only an essential component of student retention, but also influences students' success in distance learning (Bond & Lockee, 2014). The concept of a classroom community refers to the sense that members matter to one another and to the group, that they have responsibilities and obligations to one another and to the school, and that they have shared expectations, through which members' educational needs will be satisfied via shared learning goals (Rovai, 2002).

Connectedness and learning comprise two components of a classroom community in online studies. Rovai (2002) identified the following four essential prerequisites to support the development of a sense of community in an online class: spirit (recognition of membership), trust (willingness to rely on other team members), interaction (either task-driven or socio-emotional in origin), and the commonality of expectations and goals (learning). A sense of community in online classes is essential to promote students' satisfaction and help them feel connected and engaged. Instructors and faculty members are responsible for building students' sense of community in online classes by designing interactive learning experiences (Glazier, 2016). Many authors have stated that student-faculty connections foster students' sense of community, belonging, cohesiveness, and engagement. In their studies, students seemed to value their relationship with their instructors, which is a proven predictor of students' satisfaction with online learning (Ali & Ahmad, 2011; Lee & Bonk, 2016; Luo et al., 2017; Smith, 2016). Online discussions facilitate interactions among students and provide them with opportunities to discuss academic and personal experiences with their peers (Shackelford & Maxwell, 2012).

Creating an online community was found to positively affect the quality of education as well as students' engagement and motivation. A meaningful online educational experience is one that is rooted inside the community of inquiry (COI), made up of the most important participants in the learning process: students and instructors (Fiock, 2020). The COI is a model that focuses on the promotion of meaningful learning experiences through the use of three factors: cognitive presence, which is reflected in students' engagement with the course materials; social presence, represented by students' involvement with other learners and cultural aspects of the learning environment; and instructional presence, which is symbolized by students' interaction with instructional methods and learning activities (Fiock, 2020).

Learning occurs when students participate, engage, and collaborate with each other (Green et al., 2017; Trespalacios & Perkins, 2016). Instructors enhance students' sense of community through regular communication, quality feedback, support, and interactions with the students (Green et al., 2017; LaBarbera, 2013). Furthermore, synchronous activities allow students to learn and interact with their peers and instructors (Rockinson-Szapkiw et al., 2016). Different tools and strategies have been identified to enhance students' sense of community in online classes, such as social networking platforms (Rockinson-Szapkiw et al., 2016), video conferencing (Armstrong et al., 2018), asynchronous discussion boards (Trespalacios & Perkins, 2016), and collaborative tools such as Google Workspace (Abdelmalak, 2015).

A major challenge that nursing students could face during e-learning is the lack of social presence (Mayne & Wu, 2011). Social presence is considered one of the factors required for creating a successful online learning experience. It is defined in the COI model as the ability of individuals to project their personal traits into the community, thus presenting themselves to the other participants as "actual people" (Fiock, 2020).

Prior studies have reported a positive association between a sense of community in online classes and student satisfaction (Moore, 2014; Shackelford & Maxwell, 2012). Perceived learning, satisfaction, engagement, and achievements were also positively influenced by the sense of community in online classes (Glazier, 2016; Top, 2012). LaBarbera (2013) reported that students' satisfaction with online classes was greater among those who felt engaged and got along with their classmates and instructors. However, studies comparing students' sense of community in online and face-to-face classes found that students experienced a higher level of satisfaction in the latter (Ritter & Polnick, 2008). The unexpected switch to online learning caused by the pandemic may have affected students' sense of community and satisfaction, especially in cases where instructors lacked the skills to successfully implement strategies to create a classroom community in this context (Robinson & Hope, 2013; Vilppu et al., 2019). In this regard, it is worth noting that studies examining the influence of a sense of community and satisfaction with e-learning on nursing students' academic achievement are lacking.

Student responses are vital indicators of concern regarding online courses as they reflect variations in the sense of community, especially in distance learning. A sense of community can be achieved desirably, in a well-structured manner, to facilitate the satisfaction and comfort of online learners regarding knowledge acquisition. Therefore, this study aimed to assess students' sense of community and satisfaction during e-learning and determine their impact on students' academic achievement.

Methodology

Design and Sampling

This was a cross-sectional, descriptive study. The study data were collected at a single point in time using the convenience sampling method. The inclusion criteria were as follows: (a) current enrollment as an undergraduate nursing student, (b) prior or current enrollment in practical courses (e.g., health assessment, adult, or critical care courses), (c) current enrollment in courses that were completely online or hybrid, and (d) proficiency in English, as the study questionnaires were not translated into Arabic. Interns who were no longer taking theoretical and clinical courses were excluded.

G*Power software, release 3.1 (https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower), was employed to determine the sample size. A minimum of 82 participants were required to run the bivariate Pearson's correlation and independent sample *t*-test. The final sample size in this study was 103.

Participants and Procedures

As the education system was largely run online across the country during the initial phase of the COVID-19 pandemic, nursing students were recruited using social media, such as Twitter, student clubs, and university e-mail accounts. Nursing students were recruited from a public university in SA.

Anonymous surveys were created using an online platform. Students were presented with the recruitment statement, the classroom community scale, and the student outcomes survey during the semester and prior to final exams. The recruitment statement included specific information regarding participants' privacy, confidentiality, and the risks and benefits of participation. Students were informed that participation in this study was completely voluntary and that there would be no consequences if they decided to withdraw. Moreover, students were informed that no identifiers, except the university identifier, would be collected, and that all gathered data would be reported in aggregate form.

Table 1 shows the demographic characteristics of the participants (n = 103). The students' ages ranged from 18 to 23 years, with the majority being 18 to 20 years old (63.1%). Female students comprised the majority of the study sample (84.5%). Regarding the level of education, all students were enrolled at the time in a bachelor's program in nursing (BSN), with junior students representing the majority of the sample (59.2%). The mean sample academic achievement score was 3.59 (SD = 0.55), with a possible range of 1–5.

Table 1

Sample Characteristics of the Participants

Characteristic	*n*	%
Age (years)		
18–20	65	63.1
21–23	38	36.9
Gender		
Male	16	15.5
Female	87	84.5
Level of education		
Junior	61	59.2
Senior	42	40.8

Note. N = 103. The mean GPA was 3.59 (SD = 0.55).

Measures

The participants completed a sociodemographic form that collected information on age, sex, and their current semester in nursing school. The students' grade point average (GPA) was extracted from the registration records using the university identifier.

In addition, students completed the student outcomes survey, a self-reported instrument aimed at measuring students' satisfaction with their learning. It included 19 items and three subscales (i.e., teaching, assessment, and generic skills and learning experiences; Fieger, 2012). All items were rated on a 5-point Likert scale that ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Higher scores indicated a greater level of satisfaction. This instrument was previously used with the same population and demonstrated reliable and valid results (Alqahtani et al., 2021).

In this study, the Cronbach's alpha (α) values were .92 for teaching, .94 for assessment, and .95 for generic skills and learning experiences. The overall reliability of the scale was .93, thus indicating the reliability and suitability of the scale (see Table 2).

Finally, students completed the classroom community scale, which measures the sense of community in a particular learning environment (Rovai, 2002). This self-reported measure comprised 20 items and two subscales: connectedness and learning. Each item was measured on a 5-point Likert scale ranging from *strongly agree* to *strongly disagree*. Specific items within each subscale were reverse-coded in this study to ensure that the least favorable choice imparted a low value and the most favorable choice was assigned a high value. This instrument has previously shown reliable and valid results, with a Cronbach's α of .93 (Rovai, 2002). In this study, the Cronbach's α values were .75 for connectedness and .70 for learning, which were toward the lower end of acceptability. The overall reliability of the scale was .72.

Data Analysis

IBM SPSS Statistics software (Version 28) was used to analyze the results. Data management and cleanup were completed prior to the analysis. Descriptive statistics (*M*, *SD*, and percentage values) were used to describe the demographic characteristics and missing data across all variables. Except for the demographic questions, all items were completed using the force completion option. None of the variables had more than 5% missing data. The reliability coefficient was calculated for the scales and subscales. Bivariate correlation was used to assess the association between sense of community, students' satisfaction, and GPA.

An independent sample *t*-test was used to determine the relationship between nursing students' characteristics and the outcome variables.

Ethical Considerations

Approval from the appropriate ethics committee (Institutional Review Board) was obtained prior to study onset. Permission to use the instruments was obtained from the authors prior to data collection. Participants signed an informed consent form prior to filling out the questionnaire.

Findings

Table 2 shows the average score and reliability coefficient for students' sense of community and satisfaction regarding e-learning. The average score on the sense of community scale was moderate ($M = 3.3$, $SD = 0.62$). However, the total students' satisfaction score was high ($M = 3.99$, $SD = 1.00$), indicating that students were satisfied with the e-learning system.

Table 2

Average Scores and Reliability of the Scales

Variable	*M*	*SD*	Cronbach's α
Sense of community scale	3.3	.62	.72
Connectedness	3.33	.69	.75
Learning	3.25	.62	.70
Satisfaction scale	3.99	.87	.93
Teaching	4.22	.83	.94
Assessment	3.86	.97	.92
Generic skills and learning experiences	3.89	1.0	.95

Association Between Sense of Community, Satisfaction with E-Learning, and Academic Achievement

Table 3 presents the correlation matrix for sense of community, total satisfaction with e-learning and its subscales, and students' academic achievement (GPA). The bivariate correlation showed a positive and significant correlation between the sense of community and satisfaction with teaching (r = .269, p < .001), assessment (r = .258, p < .001), generic skills and learning experiences (r = .238, p < .01), academic achievement (r = .526, p < .001), and total satisfaction with e-learning (r = .272, p < .001). Academic achievement (GPA) was positively and strongly correlated with teaching (r = .454, p < .001), assessment (r = 455, p < .001), generic skills and learning experiences (r = 439, p < .001), and total satisfaction with e-learning (r = 480, p < .001).

Table 3

Correlation Matrix for Sense of Community, Total Satisfaction with E-Learning and its Subscales, and Academic Achievement

Variable	1	2	3	4	5	6
1. Sense of community	—					
2. Teaching subscale	.269**	—				
3. Assessment subscale	.258**	.809**	—			
4. Generic skills and learning experiences	.238*	.750**	.852**	—		
5. Total satisfaction with e-learning	.272**	.905**	.954**	.937**	—	
6. Academic achievement (GPA)	526**	454**	.455**	.439**	.480**	—

Note. N = 103. Pearson's correlation was used. *p < .01. **p < .001

Relationship Between Demographic Characteristics, Sense of Community, Total Satisfaction with E-Learning, and Academic Achievement

Regarding the sample characteristics (Table 4), there was no statistically significant difference among the age groups regarding sense of community, overall satisfaction with e-learning, and GPA. However, gender showed significant associations with a sense of community, overall satisfaction with e-learning, and academic achievement. Specifically, female participants reported a strong sense of community (t = 1.69, p < .05), total satisfaction with e-learning (t = 2.29, p < .05), and greater academic achievement (t = 2.04, p < .05) compared to male students. Additionally, there was a statistically significant difference between junior and senior students in terms of total satisfaction with e-learning and academic achievement. Junior students had higher satisfaction scores (t = 3.51, p < .001) and higher GPAs (t = 2.44, p < .01). This may indicate that it is feasible for junior students to learn nursing skills using e-learning before the onset of clinical practice. However, applying nursing skills may require physical attendance, which could explain the lower satisfaction levels toward e-learning and lower academic performance of senior students.

Table 4

Differences Between the Sample Characteristics and Sense of Community, Total Satisfaction with E-Learning, and Academic Achievement

Characteristic	Sense of community				Total satisfaction with e-learning				Academic achievement			
	M	*SD*	*t*	*p*	*M*	*SD*	*t*	*p*	*M*	*SD*	*t*	*p*
Age												
18–20	3.23	.69	1.07	.14	4.0	.86	1.43	.07	3.61	.58	.323	.37
21–23	3.37	.48			3.83	.87			3.57	.49		
Gender												
Male	3.04	.81	1.69	.04*	3.44	1.0	2.29	.017*	3.34	.56	2.04	.02*
Female	3.33	.58			4.09	.79			3.64	.53		
Education												
Junior	3.35	.58	1.32	.09	4.25	.57	3.51	<.001**	3.70	.50	2.44	.008**
Senior	3.19	.68			3.61	1.07			3.43	.58		

Note. N = 103. Independent sample t test was used. $^{*}p < .05$. $^{**}p < .01$.

Discussion

Online education has emerged as an essential component of the Saudi Arabian education system. In particular, it has established its significance by enabling students to continue their learning during the COVID-19 pandemic. However, evaluating the effectiveness of online education in SA is challenging due to differences in students' schooling levels, specialty types, and age groups. Recent studies have reported contradictory results regarding the effectiveness of online learning in SA.

The results of our study in terms of high satisfaction with e-learning are in line with the findings of Aboud (2021), although a number of students faced some issues with information technology resources. With respect to community and participation, our results comply with those of Mahyoob (2021), who exhibited the success of online learning in his study of the parameters of preference, participation, and assessment.

In our study, nursing students were satisfied with e-learning, which is consistent with previous studies (Abbasi et al., 2020; Alqahtani et al., 2021). Moreover, our study exhibited a significant, positive, and strong relationship between the sense of community, satisfaction with e-learning, and students' academic achievement. These results are in line with the research conducted by Rajabalee and Santally (2021), who collected data from students in different disciplines and found a significant relationship between learners' engagement and satisfaction with the learning-teaching process.

Furthermore, the findings of our study indicated that the level of satisfaction was also directly associated with students' academic achievement, and these findings are consistent with the study conducted by Jawad and Shalash (2020), who revealed that implementing e-learning strategies for college students improved students' academic achievement. In one study, perceived interactions with other students had the greatest effect (30%) on student satisfaction (Asoodar et al., 2016), and these findings are consistent with our research, which also exhibited a positive relationship between the sense of connectedness and community and satisfaction in terms of teaching, knowledge acquired, and assessment methodology.

Other studies have stressed the importance of blended learning in students' academic achievements (Alshawish et al., 2021; Alvarez et al., 2017; Leidl et al., 2020). Blended learning differs from e-learning, enabling instructors to integrate technology with traditional face-to-face teaching. In e-learning, courses are taught completely online with few or no face-to-face interactions. Ghasemi et al. (2020) reported that the level of engagement in academic learning influenced nursing students' success. Previous research indicated that the high frequency of meetings between nursing students and their mentors increased students' satisfaction with the clinical learning environment (Papastavrou et al., 2016). It is worth mentioning that previous studies did not assess the learning outcomes for senior nursing students. Students at advanced levels need to apply their nursing skills under supervision, which could enhance their satisfaction with the learning strategies and, in turn, enhance their learning outcomes. This could explain the low levels of satisfaction and academic achievement among senior nursing students observed in our study. To date, few studies have focused on the sense of community and satisfaction with e-learning among nursing students, which prevents us from drawing comparisons.

We also specified how nursing students' satisfaction with e-learning influenced their academic achievement. We found that students' GPA was positively and significantly associated with teaching, generic skills, and learning experiences. This result is congruent with the work of Ludin and Fathullah (2016), who found that clinical teaching behaviors had a strong influence on nursing students' learning. Pournamdar (2015) collected data from 165 nursing students to understand their perceptions of the characteristics of effective instructors. The students revealed that applying appropriate teaching methods was one of the highest rated characteristics of instructors (Pournamdar, 2015).

Female participants in this study reported a strong sense of community within the e-learning system compared to their male counterparts. This result is consistent with previous studies conducted in Western countries (Johnson, 2011; Tsai et al., 2015), which found that female students perceived greater social presence during online learning compared to male students. We also found that female participants had higher satisfaction and GPAs compared to male students. Jawad and Shalash (2020) evaluated the effects of a sudden transition to e-learning among Palestinian nursing students and concluded that despite the overall increase in students' GPAs after the implementation of e-learning, female students had higher GPAs than male students. One reason for this may be the fact that a higher number of respondents or participants were female, which could influence the average GPA of the total sample size.

Moreover, we found that students at lower levels of nursing school had higher satisfaction rates compared to those at advanced levels. This result is consistent with previous research studies. Papastavrou et al. (2016) found that first-year nursing students had higher satisfaction levels compared to students in other years (Papastavrou et al., 2016). Nursing students at lower levels learn nursing skills prior to the onset of clinical practice (Jeong, 2017), which may be more feasible through e-learning, whereas those at advanced levels, such as students in their internship year, must apply their acquired nursing skills in clinical settings

(Grande et al., 2021). Similar findings were also reported by Abbasi et al. (2020), who found that more than two thirds of the nursing students who participated in their study believed that practical skills were best learned in clinical settings. Thus, the evaluation of clinical competence among nursing students at advanced levels, specifically those who participated in e-learning, warrants further investigation.

Nursing researchers have raised the question of how nursing education can be successfully delivered in a culture of social distancing in real-world clinical practice (Dewart et al., 2020; Natarajan & Joseph, 2022). Some courses are clinical in nature and need a face-to-face approach. Thus, it is unsurprising that senior students in this study expressed concern about being able to successfully earn their degree without reaching students' learning outcomes.

Implications

Education is among the basic pillars facilitating the development of a country. Since the onset of the COVID-19 pandemic, the online learning medium has been predominantly used in education systems (Alqahtani et al., 2021). In this context, our study is relevant as it has implications for the future of teaching and learning in technology-enabled learning environments. Online learning has not only disrupted traditional teaching practices, but also created difficulties for instructors in adapting to this medium. Failure to meet students' expectations can lead to low levels of student involvement. Thus, students' satisfaction and engagement are good indicators of the quality and effectiveness of online programs. Nursing programs must determine whether their students are satisfied with their learning experience. Repeating this investigation is necessary to adopt appropriate policies for the survival of the education system. Therefore, higher education institutions should continuously strive to create a reliable and supportive environment that includes interactive techniques to increase students' sense of community in order to increase their satisfaction with e-learning.

This study calls for further action through seminars and training sessions to introduce innovative teaching techniques and alternative assessment plans for instructors and learners. This study can help educational institutes develop effective techniques for online communication while helping them manage the possible behavioral and emotional difficulties of students during online learning courses. Instructors need to stay involved in promoting collaboration and conversations among students. Our findings also have implications for institutional e-learning policies aimed at improving learning design models, student support and counseling, and learning analytics.

Limitations

This study has some limitations. First, social desirability bias may be present in the participants' responses due to the self-reported nature of the measures. To minimize social desirability bias, the students were informed that their responses would be reported in an aggregate form. Second, we did not assess differences in the pedagogical styles of faculty members in the nursing school. We recommend that future researchers determine the differences in teaching style, quality of teaching, and quality of instructional practices and their impact on students' academic achievement. This could be assessed by adopting a between-subjects study design.

Conclusion

This study highlights the influence of nursing students' sense of community and satisfaction during e-learning on their academic achievement. It devises strategies for educational institutions to improve the level of interaction and cooperation among students using participatory teaching methods. Our findings reveal a significant relationship between a sense of community and satisfaction with e-learning and students' academic achievement, which has not been documented in previous literature.

The rise of e-learning in SA is an unexpected benefit of the COVID-19 pandemic. However, nursing students at advanced levels of schooling might not be able to maximize the benefits of e-learning due to their inability to demonstrate their skills in real-world clinical practice. In order to meet nursing students' needs, proper strategies should be implemented based on existing evidence. The national distance education plan may require further modifications to completely satisfy the needs of nursing students. The use of blended learning may help accomplish their learning objectives.

References

Abbasi, M. S., Ahmed, N., Sajjad, B., Alshahrani, A., Saeed, S., Sarfaraz, S., Alhamdan, R. S., Vohra, F., & Abduljabbar, T. (2020). E-Learning perception and satisfaction among health sciences students amid the COVID-19 pandemic. *Work: A Journal of Prevention, Assessment & Rehabilitation*, *67*(3), 549–556. https://doi.org/10.3233/WOR-203308

Abdelmalak, M. M. M. (2015). Web 2.0 technologies and building online learning communities: Students' perspectives. *Online Learning*, *19*(2). http://dx.doi.org/10.24059/olj.v19i2.413

Aboud, Y. (2021). Challenges to gifted education in the Covid-19 pandemic about online learning in Saudi Arabia from the perspective of gifted students and parents. *Journal of Gifted Education and Creativity*, *8*(1), 11–21. https://dergipark.org.tr/en/download/article-file/1465149

Alqahtani, N., Innab, A., & Bahari, G. (2021). Virtual education during COVID-19: Exploring factors associated with e-learning satisfaction among Saudi nursing students. *Nurse educator*, *46*(2), E18-E22. https://doi.org/10.1097/NNE.0000000000000954

Ali, A., & Ahmad, I. (2011). Key factors for determining student satisfaction in distance learning courses: A study of Allama Iqbal Open University. *Contemporary Educational Technology*, *2*(2), 118–134.

Alshawish, E., El-Banna, M. M., & Alrimawi, I. (2021). Comparison of blended versus traditional classrooms among undergraduate nursing students: A quasi-experimental study. *Nurse Education Today*, *106*, Article 105049. https://doi.org/10.1016/j.nedt.2021.105049

Alvarez, A. G., Dal Sasso, G. T. M., & Iyengar, M. S. (2017). Persuasive technology in teaching acute pain assessment in nursing: Results in learning based on pre and post-testing. *Nurse Education Today*, *50*, 109–114. https://doi.org/10.1016/j.nedt.2016.12.019

Armstrong, S. N., Early, J. O., Burcin, M. M., Bolin, K., Holland, N., & No, S. (2018). New media tools impact on online, health science students' academic persistence and support: Lessons learned from two pilot studies. *TechTrends: Linking Research and Practice to Improve Learning*, *62*(3), 266–275. https://doi.org/10.1007/s11528-018-0261-1

Asoodar, M., Vaezi, S., & Izanloo, B. (2016). Framework to improve e-learner satisfaction and further strengthen e-learning implementation. *Computers in Human Behavior*, *63*, 704–716. https://doi.org/10.1016/j.chb.2016.05.060

Bdair, I. A. (2021). Nursing students' and faculty members' perspectives about online learning during COVID-19 pandemic: A qualitative study. *Teaching and Learning in Nursing*, *16*(3), 220–226. https://doi.org/10.1016/j.teln.2021.02.008

Bond, M. A., & Lockee, B. B. (2014). *Building virtual communities of practice for distance educators*. Springer.

Button, D., Harrington, A., & Belan, I. (2014). E-learning & information communication technology (ICT) in nursing education: A review of the literature. *Nurse Education Today*, *34*(10), 1311–1323. https://doi.org/10.1016/j.nedt.2013.05.002

Dewart, G., Corcoran, L., Thirsk, L., & Petrovic, K. (2020). Nursing education in a pandemic: Academic challenges in response to COVID-19. *Nurse Education Today*, *92*, Article 104471. https://doi.org/10.1016/j.nedt.2020.104471

Fieger, P. (2012). *Measuring student satisfaction from the student outcomes survey. Technical paper*. National Centre for Vocational Education Research. https://files.eric.ed.gov/fulltext/ED532394.pdf

Fiock, H. (2020). Designing a community of inquiry in online courses. *The International Review of Research in Open and Distributed Learning*, *21*(1), 135–153. https://doi.org/10.19173/irrodl.v20i5.3985

Ghasemi, M. R., Moonaghi, H. K., & Heydari, A. (2020). Strategies for sustaining and enhancing nursing students' engagement in academic and clinical settings: A narrative review. *Korean Journal of Medical Education*, *32*(2), 103–117. https://doi.org/10.3946/kjme.2020.159

Glazier, R. A. (2016). Building rapport to improve retention and success in online classes. *Journal of Political Science Education*, *12*(4), 437–456. https://doi.org/10.1080/15512169.2016.1155994

Grande, R. A. N., Butcon, V. E. R., Indonto, M. C. L., Villacorte, L. M., & Berdida, D. J. E. (2021). Quality of life of nursing internship students in Saudi Arabia during the COVID-19 pandemic: A cross-sectional study. *International Journal of Africa Nursing Sciences*, *14*, Article 100301. https://doi.org/10.1016/j.ijans.2021.100301

Green, T., Hoffmann, M., Donovan, L., & Phuntsog, N. (2017). Cultural communication characteristics and student connectedness in an online environment: Perceptions and preferences of online graduate students. *International Journal of E-Learning & Distance Education*, *32*(2), 1–29. https://www.ijede.ca/index.php/jde/article/view/1033

Jawad, Y. A. L. A., & Shalash, B. (2020). The impact of e-learning strategy on students' academic achievement. Case study: Al-Quds open university. *International Journal of Higher Education*, *9*(6), 44-53. https://doi.org/10.5430/ijhe.v9n6p44

Jeong, H. (2017). Effects of nursing students' practices using smartphone videos on fundamental nursing skills, self-efficacy, and learning satisfaction in South Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 2351–2365. https://doi.org/10.12973/eurasia.2017.01229a

Johnson, R. D. (2011). Gender differences in e-learning: Communication, social presence, and learning outcomes. *Journal of Organizational and End User Computing (JOEUC)*, *23*(1), 79–94. https://doi.org/ 10.4018/joeuc.2011010105

Khalil, R., Mansour, A. E., Fadda, W. A., Almisnid, K., Aldamegh, M., Al-Nafeesah, A., Alkhalifah, A., & Al-Wutayd, O. (2020). The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: A qualitative study exploring medical students' perspectives. *BMC Medical Education*, *20*(1), Article 285. https://doi.org/10.1186/s12909-020-02208-z

LaBarbera, R. (2013). The relationship between students' perceived sense of connectedness to the instructor and satisfaction in online courses. *Quarterly Review of Distance Education*, *14*(4), 209–220. https://eric.ed.gov/?id=EJ1144797

Leidl, D. M., Ritchie, L., & Moslemi, N. (2020). Blended learning in undergraduate nursing education–A scoping review. *Nurse Education Today*, *86*, Article 104318. https://doi.org/10.1016/j.nedt.2019.104318

Lee, J., & Bonk, C. J. (2016). Social network analysis of peer relationships and online interactions in a blended class using blogs. *The Internet and Higher Education*, *28*, 35–44. https://doi.org/10.1016/j.iheduc.2015.09.001

Ludin, S. M., & Fathullah, N. M. N. (2016). Undergraduate nursing students' perceptions of the effectiveness of clinical teaching behaviours in Malaysia: A cross-sectional, correlational survey. *Nurse Education Today*, *44*, 79–85. https://doi.org/10.1016/j.nedt.2016.05.007

Luo, N., Zhang, M., & Qi, D. (2017). Effects of different interactions on students' sense of community in e-learning environment. *Computers & Education*, *115*, 153–160. https://doi.org/10.1016/j.compedu.2017.08.006

Mahyoob, M. (2021). Online learning effectiveness during the COVID-19 pandemic: A case study of Saudi universities. *International Journal of Information and Communication Technology Education (IJICTE)*, *17*(4), 1–14. https://doi.org/10.4018/IJICTE.20211001.oa7

Mayne, L. A., & Wu, Q. (2011). Creating and measuring social presence in online graduate nursing courses. *Nursing Education Perspectives*, *32*(2), 110. https://doi.org/10.5480/1536-5026-32.2.110

Moore, R. L. (2014). Importance of developing community in distance education courses. *TechTrends: Linking Research and Practice to Improve Learning*, *58*(2), 20–24. https://doi.org/10.1007/s11528-014-0733-x

Mukhtar, K., Javed, K., Arooj, M., & Sethi, A. (2020). Advantages, limitations and recommendations for online learning during COVID-19 pandemic era. *Pakistan Journal of Medical Sciences*, *36*(COVID19-S4), S27–S31. https://doi.org/10.12669/pjms.36.COVID19-S4.2785

Murphy, B. (2020, March 18). *COVID-19: How the virus is impacting medical schools*. American Medical Association. https://www.ama-assn.org/delivering-care/public-health/covid-19-how-virus-impacting-medical-schools

Natarajan, J., & Joseph, M. A. (2022). Impact of emergency remote teaching on nursing students' engagement, social presence, and satisfaction during the COVID-19 pandemic. *Nursing Forum*, *57*(1), 42–48. https://doi.org/10.1111/nuf.12649

Opeyemi, O. Z., Adeyemi, A. A., Olajuwon, T. D., Oloruntosin, O. N., & Oladeji, B. S. (2019). Perception of nursing students towards online learning: A case study of Lautech Open and Distance Learning Centre, Ogbomoso, Oyo State, Nigeria. *Galore International Journal of Health Sciences and Research*, *4*(4), 23–30. https://www.gijhsr.com/GIJHSR_Vol.4_Issue.4_Oct2019/5.pdf

Papastavrou, E., Dimitriadou, M., Tsangari, H., & Andreou, C. (2016). Nursing students' satisfaction of the clinical learning environment: A research study. *BMC Nursing*, *15*(1), Article 44. https://doi.org/10.1186/s12912-016-0164-4

Pournamdar, Z. (2015). Study of characteristics of an effective clinical instructor from nursing students' point of view in Zahedan. *Researcher*, *5*(7), 5.

Rajabalee, Y. B., & Santally, M. I. (2021). Learner satisfaction, engagement and performances in an online module: Implications for institutional e-learning policy. *Education and Information Technologies*, *26*(3), 2623–2656. https://doi.org/10.1007/s10639-020-10375-1

Ritter, C., & Polnick, B. (2008). Connections: An essential element of online learning communities. *International Journal of Educational Leadership Preparation*, *3*(3), 1–5. https://eric.ed.gov/?id=EJ1067185

Robinson, T. E., & Hope, W. C. (2013). Teaching in higher education: Is there a need for training in pedagogy in graduate degree programs? *Research in Higher Education Journal*, *21*, 1–11. https://eric.ed.gov/?id=EJ1064657

Rockinson-Szapkiw, A., Wendt, J., Whighting, M., & Nisbet, D. (2016). The predictive relationship among the community of inquiry framework, perceived learning and online, and graduate students' course grades in online synchronous and asynchronous courses. *The International Review of Research in Open and Distributed Learning*, *17*(3). https://doi.org/10.19173/irrodl.v17i3.2203

Rovai, A. P. (2002). Development of an instrument to measure classroom community. *The Internet and Higher Education*, *5*(3), 197–211. https://doi.org/10.1016/S1096-7516(02)00102-1

Shackelford, J. L., & Maxwell, M. (2012). Sense of community in graduate online education: Contribution of learner to learner interaction. *International Review of Research in Open and Distance Learning*, *13*(4), 228–249. https://doi.org/10.19173/irrodl.v13i4.1339

Sinaga, J., Eka, N. G. A., & Sitanggang, Y. F. (2018). Nursing students' learning experiences in an online learning course. *Nursing Current: Jurnal Keperawatan*, *6*(1), 43–49. http://dx.doi.org/10.19166/nc.v6i1.1285

Smith, E. E. (2016). "A real double-edged sword:" Undergraduate perceptions of social media in their learning. *Computers & Education*, *103*, 44–58. https://doi.org/10.1016/j.compedu.2016.09.009

Suliman, W. A., Abu-Moghli, F. A., Khalaf, I., Zumot, A. F., & Nabolsi, M. (2021). Experiences of nursing students under the unprecedented abrupt online learning format forced by the national curfew due to COVID-19: A qualitative research study. *Nurse Education Today*, *100*, Article 104829. https://doi.org/10.1016/j.nedt.2021.104829

Tang, A. C. Y., Wong, N., & Wong, T. K. S. (2015). Learning experience of Chinese nursing students in an online clinical English course: Qualitative study. *Nurse Education Today*, *35*(2), e61–e66. https://doi.org/10.1016/j.nedt.2014.11.017

Taylor, D., Grant, J., Hamdy, H., Grant, L., Marei, H., & Venkatramana, M. (2020). Transformation to learning from a distance [version 1]. *MedEdPublish*, *9*(76). https://doi.org/10.15694/mep.2020.000076.1

Top, E. (2012). Blogging as a social medium in undergraduate courses: Sense of community best predictor of perceived learning. *The Internet and Higher Education*, *15*(1), 24–28. https://doi.org/10.1016/j.iheduc.2011.02.001

Trespalacios, J., & Perkins, R. (2016). Sense of community, perceived learning, and achievement relationship in an online graduate course. *Turkish Online Journal of Distance Education*, *17*(3), 31–49. https://dergipark.org.tr/en/pub/tojde/issue/24146/256257

Tsai, M.-J., Liang, J.-C., Hou, H.-T., & Tsai, C.-C. (2015). Males are not as active as females in online discussion: Gender differences in face-to-face and online discussion strategies. *Australasian Journal of Educational Technology*, *31*(3). https://doi.org/10.14742/ajet.1557

Vilppu, H., Södervik, I., Postareff, L., & Murtonen, M. (2019). The effect of short online pedagogical training on university teachers' interpretations of teaching–learning situations. *Instructional Science*, *47*(6), 679–709. https://doi.org/10.1007/s11251-019-09496-z

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Technology Enabling the New Normal: How Students Respond to Classes

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Abstract

This cross-sectional study investigates the online education intention of undergraduate students in the largest and oldest public university in Bangladesh during the COVID-19 pandemic. Under convenient sampling, 843 undergraduate students with rural and urban backgrounds participated in an online self-administered questionnaire. Partial least squares structural equation modelling (PLS-SEM) was employed to examine the hypothesized relationships. We found that students' online class intention is significantly influenced by their attitude towards online classes (AOC), perceived usefulness (PU), and facilitating conditions (FC). We further identified that external antecedents have significant indirect effects on the outcome variables. Our findings provide new insights and contribute to a learners' community on online classes during the COVID-19 pandemic. This study extends the technology acceptance model (TAM) and the theory of planned behavior (TPB) to depict the factors influencing undergraduate students' intention to attend online classes (IOC) during the COVID-19 pandemic.

Keywords: COVID-19, online class intention, technology acceptance model, theory of planned behavior, Bangladesh

Introduction

In response to the worldwide emergency caused by the COVID-19 pandemic, many universities closed their on-campus academic activities and initiated online classes (Daniel, 2020; Murphy, 2020). Unlike adopting or accepting online learning as an alternative to face-to-face classes, the phenomenon of online learning during COVID-19 was merely a solution to address specific problems that the academic institutions were facing during the crisis (Dhawan, 2020). However, the rapid shift from a face-to-face classroom environment to online classes is creating various challenges (Crawford et al., 2020). Academics who normally conduct face-to-face lectures and communications may not be finding the new mode comfortable. Furthermore, students' adaptation capacity widely varies across countries. There remains ample scope for new research into the intention to use online education for both contextualization and theoretical extension.

During the COVID-19 pandemic, Bangladesh has been one of the most affected nations in the world (Bodrud-Doza et al., 2020). After detecting the first case in Bangladesh, authorities decided to shutdown academic activities on campuses in March 2020 (Anwar et al., 2020; Khan et al., 2020) to ensure social distancing as it is believed to be effective against transmission of the virus (Venkatesh & Edirappuli, 2020). Several months after the shutdown of on-campus academic activities, public universities in Bangladesh started using online education platforms with students (Al-Amin et al., 2021) though most academic institutions were yet to adopt well-established learning management systems (LMS) such as Moodle, Brightspace, WebCT, Blackboard, and Desire2Learn. Instead, online classes were conducted using Zoom, Google Meet, Webex, and other social media platforms that are not well developed LMSs.

Although the online class has been adopted globally as a tool during the crisis, the success of online learning largely depends on users' acceptance. Countries with limitations in technological advancement are not ready to implement online education (Sintema, 2020). Bangladesh does not belong among technologically developed countries as it was ranked 147th in the ICT Development Index among 176 countries in 2017 (Chowhan & Ghosh, 2020). The educational institutions of Bangladesh are at an early stage of adopting e-learning technologies for academic purposes, and the experience of using such technologies is new for both academics and students (Sarker et al., 2019). As online learning is a current phenomenon in Bangladesh, not much research has been conducted regarding the attitude and behavioral intention of students in the context of an online class. Since the online class during COVID-19 is not similar to a well-developed LMS, it is also essential to assess the experience of students and their attitudes about online academic activities. Therefore, we investigated the online class intentions of undergraduate students in a public university in Bangladesh, where online classes officially started several months after lockdown came into force in March 2020. The research was intended to extend available literature, incorporating new antecedents of online class intentions and unveiling the context of a lower middle income country where more than 3.2 million people are enrolled at the tertiary level of education (Mannan, 2017).

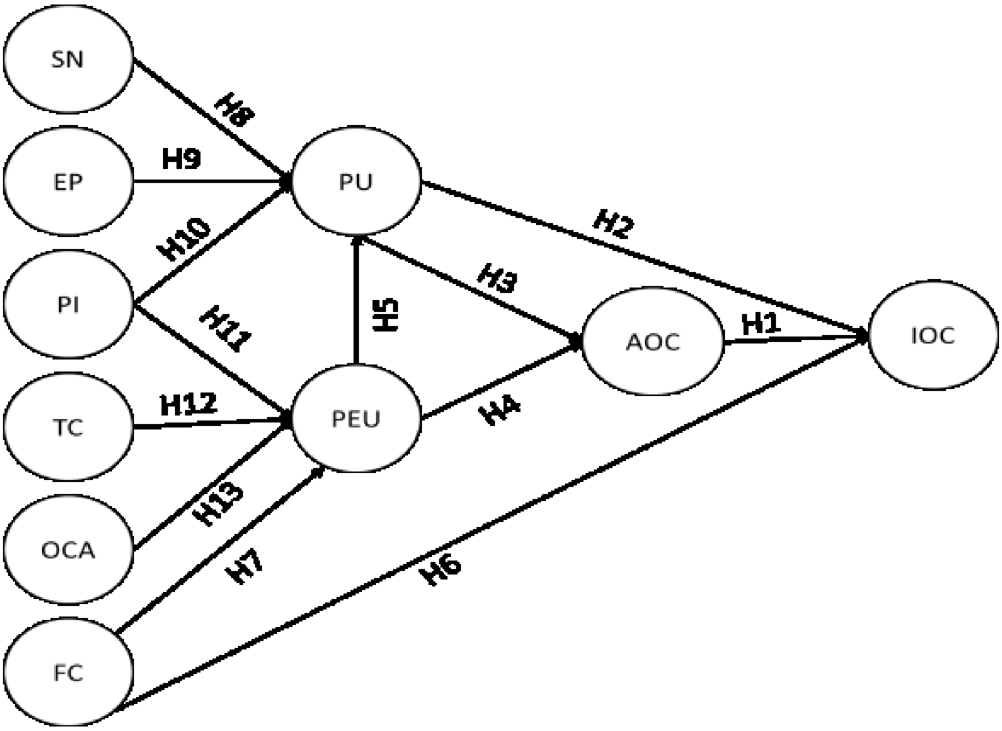
Literature and Hypotheses Development

Intention to Attend Online Classes (IOC)

Several factors affect behavioral intention. According to the technology acceptance model (TAM), attitude, perceived usefulness (PU), and perceived ease of use (PEU) influence behavioral intention (Davis, 1989). Aligned with the TAM, we investigated how attitude, PU, and PEU influenced students' intention to attend online classes during COVID-19. We also extended the TAM by adding four variables: personal innovativeness (PI), technological complexity (TC), expected performance (EP), and facilitating conditions (FC). Figure 1 summarizes our research model.

Figure 1

Research Model



Note. SN = subjective norm; EP = expected performance; PI = personal innovativeness; TC = technological complexity; OCA = online class anxiety; FC = facilitating condition; PU = perceived usefulness; PEU = perceived ease of use; AOC = attitude towards online classes; IOC = intention to attend online classes; H = hypothesis.

Attitude Towards Online Class (AOC)

Attitude is widely held to be a person's positive or negative feeling about performing a target behavior (Fishbein & Azjen, 1980). Attitude deals with the possibility of performing and accepting a specific behavior (Davis, 1989; Hao, 2004). According to Kaplan (1972), the term attitude refers to the response tendency, favorable or unfavorable, to an event. In this study, attitude indicates whether students are interested in online classes, have positive feelings, and are willing to participate in an online class. Students' positive or negative attitude contributes to their online learning activities and their behavioral intention to use updated technology for learning (Venkatesh & Davis, 2000). Mailizar et al. (2021) identified that attitude positively influences the behavioral intention towards using online classes. Therefore, we set the following hypothesis:

H1: AOC positively influences IOC during COVID-19.

Perceived Usefulness (PU)

PU of technologies is one of the vital elements of the TAM. PU refers to the degree to which students using a particular system believe that it would improve their study performance and be more advantageous than earlier methods of study (Abdullah et al., 2016; Liu et al., 2009). PU influences a user's choice of whether to admit or refuse a particular technology. In accordance with the TAM (Davis, 1985), students' PU influences their attitude towards online learning through the use of technology. Moreover, PU has been consistently found to be a direct determinant of e-learning (Liu et al., 2009). With regards to the relationship between PU and IOC, Rizun and Strzelecki (2020) found that PU positively influences AOC. As such, we expect:

H2: PU positively influences IOC during COVID-19.

H3: PU positively influences AOC during COVID-19.

Perceived Ease of Use (PEU)

PEU refers to how quickly and confidently people believe that they can use a technology (Esteban-Millat et al., 2018). According to the TAM, PEU is one predictor of users' attitudes towards technology adoption (Davis, 1989). Studies suggest that PEU positively influences learning attitudes about online classes (Rizun & Strzelecki, 2020). Besides, earlier studies have confirmed that PEU could positively and significantly influence PU (Abdullah et al., 2016; Binyamin et al., 2019). Moreover, several studies (Al-Fraihat et al., 2020; Vanduhe et al., 2020) on online learning proved that PEU affects PU. In line with earlier evidence on PEU, it is likely that when students hold positive perceptions of the ease of using technologies, they consider virtual classes useful and embrace them without hesitation. Based on previous studies, the following hypotheses are postulated:

H4: PEU is positively related to AOC during COVID-19.

H5: PEU is positively related to PU of online learning during COVID-19.

Facilitating Condition (FC)

The term facilitating condition refers to whether an individual believes that sufficient infrastructure is available to use a specific system (Venkatesh et al., 2003). FC indicates the state where all the required facilities, tools, equipment, and assistance are supplied to an individual to use a system. Prior studies reveal that FC significantly influences students' intention to use interactive e-learning systems in a learning environment (Teo, 2010; Wong et al., 2013). Earlier research also demonstrated that FC predicted the PEU of web-based learning and assessment (Nikou & Economides, 2017). Sukendro et al. (2020) identified a positive relationship between FC and PEU in e-learning during COVID-19. Thus, we expect:

H6: FC positively influences IOC during COVID-19.

H7: FC positively influences PEU of online classes during COVID-19.

Subjective Norm (SN)

According to Fishbein and Ajzen (1975), SN refers to the degree of individual attention affected by other societal members' views while taking a specific decision. It assumes that an individual's belief about whether to carry out a specific behavior is significantly influenced by the judgment of others. Several studies have indicated that SN is one of the vital factors in the uptake of technology-based services (Venkatesh & Davis, 2000; Yang et al., 2012). Moreover, favorable opinions of relatives, friends, peers, and family members induce an individual to take up new services, and the individual begins to perceive that these services are useful (Schepers & Wetzels, 2007). Venkatesh and Bala (2008) and Teo et al. (2019) suggested that SN has a significant influence on PU. In the case of students, their teachers, friends, peers, and family members are regarded as significant influencers on adopting technology to assist with attending online classes (Teo, 2012). Based on this discussion, the following hypothesis has been developed:

H8: SN has a positive influence on PU of online classes during COVID-19.

Expected Performance (EP)

Expected performance is often seen as an individual's perception of completing a task successfully. Venkatesh and Davis (2000) stated that EP indicates whether a system accomplishes the given tasks effectively and efficiently. In this paper, EP refers to students' perception(s) regarding the quality of learning in online classes and whether it increases their skill(s) and academic performance and effectively equips them. Moreover, Venkatesh and Davis (2000) mentioned a correlation between output quality and PU, which was later empirically tested in the TAM (Jan & Contreras, 2016; Venkatesh & Bala, 2008). These studies indicated that the PU of a system is formed by an individuals' perception of how well the system might accomplish the given tasks and their mental assessments of the performance from applying that system (Venkatesh & Bala, 2008). We hypothesize that EP may influence students' PU of technology.

H9: EP positively influences PU of online classes during COVID-19.

Personal Innovativeness (PI)

Personal innovativeness denotes the traits that explain a person's willingness to find and adopt new technology and search for ways to experiment with it. In a broader sense, PI indicates whether a person is willing to adopt technologies or ideas that surpass the extent of their familiarity (Aldás-Manzano et al., 2009). Moreover, PI indicates an inherent side of an individual's personality, and the degree of innovativeness differs from person to person (Yang et al., 2012). Area-specific innovativeness helps users regarding the acceptance of technological innovation (Yi et al., 2006). However, an individual with a greater degree of PI in information technology in general might build up more favorable perceptions of the innovation and a better behavioral intention to accept it (Agarwal & Prasad, 1998). Thus, it is important to ascertain the role of personal innovativeness in the broader area of information technology research and technology adoption in online classes. Based on the earlier literature, we posit the following hypotheses:

H10: Students' PI positively influences their PU of online classes during COVID-19.

H11: Students' PI positively influences their PEU of online classes during COVID-19.

Technological Complexity (TC)

Technological complexity refers to the technological level that an individual requires to get familiar with a new technology and perform task(s) with it more effectively. Thompson et al. (1991) stated that TC refers to users' belief in the extent to which a technology is complicated to use. Moreover, considering human information processing capacity confines, Venkatesh and Bala (2008) recommended that TC largely influences technology users' PEU. They stated that when users find a technology is too complex, they might perceive it as challenging to use. In educational settings, TC was found to have an opposite association with students' PEU (Cigdem & Topcu, 2015; Teo, 2009). It is reasonable to expect that when students taking online classes use a technology with a greater TC than the commonly used technologies (e.g., e-mail and Microsoft Office applications), they might perceive that technology is not easy to use and more effort is required. Therefore, the following hypothesis is formulated:

H12: Students' perceived TC negatively influences PEU of online classes during COVID-19.

Online Class Anxiety (OCA)

Online class anxiety is analogous to computer anxiety and is an external antecedent to PEU. According to Hajiyev (2018), computer anxiety is characterized as the supplication of anxious or emotional reactions when accomplishing any task on a computer. Earlier research evidenced that users may feel nervous and anxious at preliminary stages of their interfaces with computers, and that such anxiety negatively influences PEU (Rizun & Strzelecki, 2020). In this study, OCA refers to students' nervousness or intimidation when attending online classes. Thus, we propose the following hypothesis:

H13: Students' OCA negatively influences PEU of online classes during COVID-19.

Method

Sample and Data

Our data comes from a convenience sample of undergraduate business students from year one to four at the University of Dhaka in Bangladesh. The University of Dhaka is Bangladesh's century-old premier public university in which students from all social strata and all geographic locations are enrolled. An online questionnaire was sent to 1700 students in May 2021 with a request to participate voluntarily and anonymously. Students were assured of the use of their responses only in aggregate. They were also given the option to withdraw from the survey at any point. The response rate was 50.17%. Over half of the respondents (52.8%) were male and from metropolitan cities (55%). In relation to the education level of the respondents' parents, it was found that 24.4% of students had a parent who had completed five years of primary education, 18% had a parent who had gone to study at the secondary level, and 18.9% had a parent who had studied at the higher-secondary level. However, the largest proportion (38.7%) had a parent who had earned a diploma or above.

Measures

All measures used a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Most of the measurement scales, shown in Table 1, were adapted from the existing literature, with modifications to address intention to use online classes during the pandemic. We developed some of the measures based on theoretical and empirical literature on the extended TAM and the theory of planned behavior (TPB). The instrument was developed in English, and the final instrument was designed based on feedback from a pilot test on 20 students.

Table 1

Measurement Scales

Construct	Measurement Item	Source
Intention to attend online class	I intend to attend all online classes.	Adapted from Zia (2020)
	I encourage my friends to attend online classes.	Developed by researchers
	I am ready to attend an examination/test online.	
	I plan a learning schedule for online classes.	Lee et al. (2019)
Attitude towards online class	The online classes are attractive to me.	Adapted from Liñán & Chen (2009)
	I am happy with online classes.	
	I am willing to participate in online class activities.	Adapted from Teo et al. (2019)
	I have positive feelings towards online classes.	
Perceived usefulness	Attending online classes has been more advantageous to me.	Adapted from Liñán & Chen (2009)
	Attending online classes helps me complete my courses.	Developed by researchers
	Attending online classes is beneficial.	
Perceived ease of use	I can easily use online class platforms.	
	I know how to use online class platform features.	
	Online classes allow flexibility.	
Subjective norm	People who influence my behavior think that I should attend online classes.	Adapted from Teo et al. (2019)
	People who are important to me think that I should attend online classes.	
	People whom I respect support me to continue online classes.	
Expected performance	The quality of learning via online classes is the same as physical classes.	Developed by researchers
	Online classes increase my skills.	
	My academic performance will not be affected by online classes.	
	Online classes offer more learning opportunities.	

Technological complexity	I have problems with the technical aspects of online classes.	Adapted from Teo et al. (2019)
	I take a long time to become familiar with the online classes tool.	
	Attending online classes is a complex activity.	
Online class anxiety	I feel nervous about online classes.	
	I hesitate to respond in online classes for fear of making mistakes.	
	Attending online classes leads to stress and anxiety for me.	
Personal innovativeness	I like to experiment with new technology.	Saadé & AlSharhan (2015)
	If I hear about new technology, I will look for ways to explore it.	
	In general, I am hesitant to try out new technology.	
	Among my peers, I am the first to try out new technology.	Yi et al. (2006)
Facilitating condition	I have the gadgets (laptop, mobile, tablet) to attend online classes.	Developed by researchers
	I have a good Internet connection.	
	I have a good Internet speed.	

Results

Analytical Framework

Apart from descriptive statistical analysis, this study implemented structural equation modeling using SmartPLS3. Mardia's multivariate test of data normality indicated significant values of skewness ($\beta = 6.33$, $p \leq 0.00$) and kurtosis ($\beta = 144.49$, $p \leq 0.00$), and therefore, PLS-SEM was suited to this data (Hair et al., 2017). Reliability and validity (convergent and discriminant) in the measurement model were tested based on the results of the PLS algorithm by using multiple indicators. The values of R^2 and f^2 are used to judge the explanatory power and effect size of the model. Using the blindfolding technique in PLS-SEM, the Stone-Geisser test was performed to ascertain the model's predictive power.

Assessment of the Measurement Model

All measurement items strongly load on the constructs and fulfill the convergent validity (Table 2). Cronbach's alpha values range from 0.74 to 0.92, and henceforth, reliability of the construct is established. Composite reliability (CR) is attained as all the values are above the threshold value of 0.7 (Hair et al., 2011). The estimated values of the average variance extracted are much greater than the threshold value of 0.5 (Sarstedt et al., 2017). Thus, there is adequate evidence of the convergent validity of the measurement model (Lin & Bautista, 2017; Venkatesh, 2000). Discriminant validity is confirmed using HT-MT$_{0.90}$, the heterotrait-monotrait ratio of correlations criterion suggested by Henseler et al. (2015). See Table 3.

Table 2

Reliability and Validity Measures

Latent variable	Item	Loading	α	AVE	CR
AOC	AOC1	0.886	0.92	0.81	0.95
	AOC2	0.89			
	AOC3	0.90			
	AOC4	0.93			
IOC	IOC1	0.88	0.85	0.69	0.90
	IOC2	0.87			
	IOC3	0.79			
	IOC4	0.78			
OCA	OCA1	0.89	0.83	0.75	0.90
	OCA2	0.87			
	OCA3	0.84			
EP	EP1	0.75	0.86	0.70	0.90
	EP2	0.87			
	EP3	0.85			
	EP4	0.88			
PEU	PEU1	0.84	0.82	0.74	0.90
	PEU2	0.89			
	PEU3	0.85			
PI	PI1	0.95	0.89	0.90	0.95
	PI2	0.95			
PU	PU1	0.85	0.82	0.74	0.90
	PU2	0.86			
	PU3	0.88			
SN	SN1	0.88	0.89	0.82	0.93
	SN2	0.94			
	SN3	0.90			
FC	FC1	0.83	0.74	0.66	0.85
	FC2	0.79			
	FC3	0.82			
TC	TC1	0.86	0.86	0.78	0.91

TC2	0.89
TC3	0.89

Note: CR = composite reliability; AOC = attitude towards online classes; IOC = intention to attend online classes; OCA = online class anxiety; EP = expected performance; PEU = perceived ease of use; PI = personal innovativeness; PU = perceived usefulness; SN = subjective norm; FC = facilitating condition; TC = technological complexity.

Table 3

Discriminant Validity (Heterotrait-Monotrait)

	AOC	IOC	OCA	PEU	PU	EP	PI	SN	TC	FC
AOC										
IOC	0.89									
OCA	0.41	0.43								
PEU	0.57	0.67	0.53							
PU	0.84	0.82	0.38	0.62						
EP	0.77	0.74	0.33	0.50	0.73					
PI	0.31	0.39	0.28	0.49	0.30	0.27				
SN	0.64	0.72	0.26	0.53	0.67	0.57	0.37			
TC	0.44	0.48	0.67	0.59	0.43	0.35	0.20	0.31		
FC	0.47	0.62	0.46	0.83	0.48	0.43	0.45	0.57	0.51	

Note. AOC = attitude towards online classes; IOC = intention to attend online classes; OCA = online class anxiety; PEU = perceived ease of use; PU = perceived usefulness; EP = expected performance; PI = personal innovativeness; SN = subjective norm; TC = technological complexity; FC = facilitating condition.

Assessment of the Structural Model

There is no evidence of multicollinearity as the variance inflation factor (VIF) scores as shown in Table 4 are much lower than the threshold value 3.3 (Hair et al., 2011). Stone-Geisser's test indicates all the endogenous latent variables have high predictive power as all the Q^2 values (Table 5) exceed the threshold limit of 0.35 (Chin, 2010). The model also has high explanatory power as it yielded high R^2 values.

Table 4 and Figure 2 indicate that 12 hypotheses were supported. IOC is positively determined by AOC ($\beta = 0.573$; $p < 0.00$), PU ($\beta = 0.192$; $p < 0.00$), and FC ($\beta = 0.199$; $p < 0.00$). Thus, H1, H2, and H6 are supported. Both PU ($\beta = 0.647$; $p < 0.00$) and PEU ($\beta = 0.168$; $p < 0.00$) are significant predictors of AOC that in turn support H3 and H4. Three variables, namely PEU ($\beta = 0.221$; $p < 0.00$), SN ($\beta = 0.297$; $p < 0.00$), and EP ($\beta = 0.386$; $p < 0.00$) have positive and significant relationships with PU. Thus, H5, H8, and H9 are supported. The relationship between PI and PU is insignificant as $p = 0.129$ and hence, H10 is not supported. Finally, PEU is negatively affected by TC ($\beta = -0.214$; $p < 0.00$) and OCA ($\beta = -0.102$; $p < 0.00$) while it is positively affected by PI ($\beta = 0.189$; $p < 0.00$) and FC ($\beta = 0.462$; $p < 0.00$). As all four predictors of PEU show significant results with expected signs, H11, H12, H13, and H7 are also supported. We also observed that f^2 values of the significant paths ranged from 0.014 to 0.701. Following the benchmark suggested by Cohen (1988), we found a significant effect size of two paths, a medium effect size of two paths, and a small effect size of eight paths.

Table 4

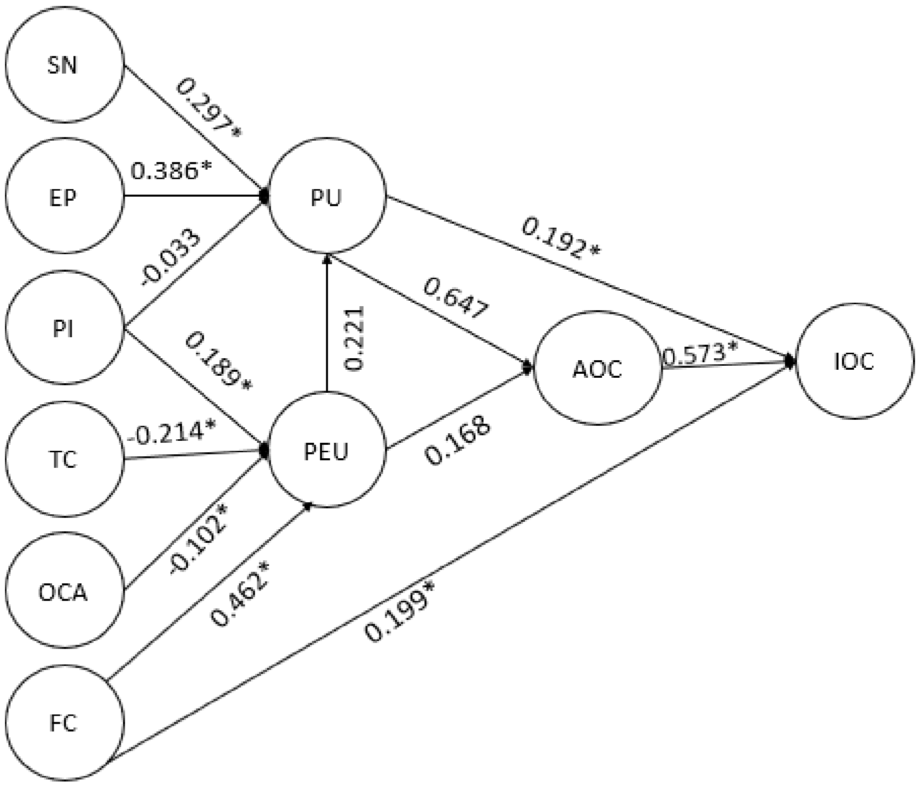
Results of the Structural Model

Hypothesis	Path	Path coefficient	*p*-value	f^2	CI (%)		VIF
					UL	*LL*	
H1	AOC→IOC	0.573	0.00	0.467	0.52	0.62	2.24
H2	PU→IOC	0.192	0.00	0.053	0.14	0.24	2.21
H3	PU→AOC	0.647	0.00	0.701	0.61	0.68	1.35
H4	PEU→AOC	0.168	0.00	0.047	0.12	0.21	1.35
H5	PEU→PU	0.221	0.00	0.067	0.17	0.27	1.50
H6	FC→IOC	0.199	0.00	0.104	0.16	0.24	1.21
H7	FC→PEU	0.462	0.00	0.335	0.41	0.51	1.36
H8	SN→PU	0.297	0.00	0.12	0.24	0.35	1.52
H9	EP→PU	0.386	0.00	0.216	0.33	0.44	1.43
H10	PI→PU	-0.033	0.12	0.002	-0.08	0.02	1.25
H11	PI→PEU	0.189	0.00	0.065	0.14	0.23	1.69
H12	TC→PEU	-0.214	0.00	0.062	0.27	0.15	1.58
H13	OCA→PEU	-0.102	0.00	0.014	-0.15	-0.04	1.54

Note. CI= confidence interval; VIF = variance inflation factor; H = hypothesis; AOC = attitude towards online classes; IOC = intention to attend online classes; PU = perceived usefulness; PEU = perceived ease of use; FC = facilitating condition; SN = subjective norm; EP = expected performance; PI = personal innovativeness; TC = technological complexity; OCA = online class anxiety.

Figure 2

Research Model with Coefficients



Note. SN = subjective norm; EP = expected performance; PI = personal innovativeness; TC = technological complexity; OCA = online class anxiety; FC = facilitating conditio; PU = perceived usefulness; PEU = perceived ease of use; AOC = attitude towards online classes; IOC = intention to attend online classes. *$p < 0.001$.

Results in Table 5 show that AOC is the most significant variable influencing intention, with a total effect of 0.57, followed by PU (0.56) and FC (0.30). PU exerts the highest direct effect on attitude. Although EP and SN positively predict PU, EP has a higher total impact (β = 0.39) than SN (β = 0.30). Results also demonstrate that among all the paths to PEU, the largest direct effect comes from FC (β = 46).

Table 5

Direct, Indirect, and Total Effects of the Research Model

Outcome	Determinant	Standardized estimate			R^2	Q^2
		Direct effects	Indirect effects	Total effects		
Intention to attend online classes	AOC	0.57		0.57	0.69	0.47
	PU	0.19	0.37	0.56		
	FC	0.20	0.10	0.30		
	EP		0.22	0.22		
	SN		0.17	0.17		
	OCA		-0.02	-0.02		
	PEU		0.22	0.22		
	TC		-0.05	-0.05		
	PI		0.02	0.02		
Attitude towards online classes	PU	0.65		0.65	0.56	0.45
	PEU	0.17	0.14	0.31		
	FC		0.14	0.14		
	OCA		-0.03	-0.03		
	EP		0.25	0.25		
	PI		0.04	0.04		
	SN		0.19	0.19		
	TC		-0.07	-0.07		
Perceived ease of Use	FC	0.46		0.46	0.53	0.39
	OCA	-0.10		-0.10		
	TC	-0.21		-0.21		
	PI	0.19		0.19		
Perceived usefulness	PEU	0.22		0.22	0.52	0.38
	SN	0.30		0.30		
	EP	0.39		0.39		
	OCA		-0.02	-0.02		
	TC		-0.05	-0.05		
	FC		0.10	0.10		
	PI	-0.03	0.04	0.01		

Note. AOC = attitude towards online classes; PU = perceived usefulness; FC = facilitating condition; EP = expected performance; SN = subjective norm; OCA = online class anxiety; PEU = perceived ease of use; TC = technological complexity; PI = personal innovativeness.

Discussion

To explore antecedents of students' intention to use online classes during the period of COVID-19, we set 13 hypotheses, of which 12 were found statistically significant. These results support the TPB (Fishbein & Ajzen, 1975, 1980), TAM2, and TAM3 (Venkatesh, 2000; Venkatesh et al., 2003; Venkatesh & Bala, 2008). We found that AOC, PU, and FC positively affect the online class intention of undergraduate students in business school. Among these variables, AOC exerts the most dominant influence on intention. This result is consistent with the studies of Sánchez and Hueros (2010) and Teo et al. (2019). Similar to the perceived behavioral control in the TPB, this study confirms the significant direct impact of FC on IOC. Prior studies did not examine the role of FC in determining students' intention to attend online classes. The effect of FC on IOC is evident given that the students participating in this study were located in diverse locations including villages, towns, and metropolitan areas where the availability of devices and quality of internet service vary to a great extent and students need to attend online classes using free versions of Zoom and Google Meet since the institution lacks an online learning management system.

In line with the assertion of the TAM and prior empirical evidence i.e., Schepers and Wetzels (2007), Teo et al., (2019), Venkatesh (2000), and Venkatesh and Bala (2008), this study finds that there is significant impact of PU and PEU on AOC. The results underscore that students are more likely to support online classes and examinations if they feel that online classes are helpful and accessible. However, the relative impact of PU is much higher than PEU, which signifies that PU has a more substantial determining effect on attitude than PEU. This result can partly be attributed to the fact that university students are familiar with online platforms and feel a degree of ease in using those technologies.

The extended TAM of this study finds that EP positively contributes to students' PU of an online class. The result implies that many students might have a negative attitude to online classes, with an apprehension that they might not perform satisfactorily, that negatively impacts their academic performance, employment opportunities, and career advancement. Similar to prior studies on the extended TAM by Jan and Contreras (2016) and Venkatesh and Bala (2008), this study supports the relationship between EP and PU in online class intention of tertiary level students. Besides, in line with the earlier evidence of the TAM by Venkatesh and Davis (2000), Schepers and Wetzels (2007), Venkatesh and Bala (2008), and Teo et al. (2019), this study confirms that the people who surround the students positively influence PU.

The PEU of an online class is predicted by four variables that PI and FC determine positively while OCA and TC affect negatively. No prior evidence on the relationship between PI and online class intention exists. However, Saadé & AlSharhan (2015) have found no impact of PI on students' motivation when using an online learning tool, while other studies (Bauer et al., 2005; Shankar & Datta, 2018) have identified PI as an important factor in technology adoption intention of customers in different cultures.

Our results indicate the positive influence of FC on PEU, and this finding is both theoretically and empirically supported by Venkatesh (2000), Venkatesh et al. (2003), and Venkatesh and Bala (2008). Besides, results demonstrate that among all the paths to PEU, the largest direct effect comes from FC. This result underscores the heightened importance of FC in the perception of ease. Thus, to promote students' PEU, the focus needs to be given to improving facilitating conditions. Moving away from the physical classroom to a virtual class is a new experience for many students. Since the new class format is a technology-enabled learning system, TC is negatively related to PEU. Teo et al. (2019) also found a negative association between TC and PEU. OCA is identified as another significant determinant of PEU, and the relationship between them is negative. Although the relationship between PEU and OCA was first examined in relation to online classes during COVID-19, our result echoed the findings of Chuo et al. (2011) and Teo et al. (2019).

Theoretical and Practical Contributions

Our research offers contributions to knowledge about online class intention. We extended the prevailing literature by adding new antecedents to the TAM (Venkatesh, 2000; Venkatesh et al., 2003; Venkatesh & Bala, 2008) and the TPB (Fishbein & Ajzen, 1975, 1980). We have extended the existing TAM in three significant ways. First, we found new variables, including OCA and PI, to be determinants of PEU of online classes while EP determines PU. Second, we developed a valid and reliable measurement of EP in online classes, which also significantly predicts PEU. Third, we have extended the measurement scales of AOC, PU, and PEU to the COVID-19 context. Altogether, our analysis has increased the predictive power and explains 69% of students' intention to accept online classes during COVID-19. As a result, this study has broadened the understanding found in the growing body of literature relating to students' intention to use online classes. In relation to the TPB, this study adds facilitating conditions as a new variable that directly impacts attitude towards online classes. FC acts as an external antecedent of PEU.

From the practical side, this study carries valuable insights for academic institutions and policymakers since there remains an ample gap in the contextual understanding of students' intentions. The underlying antecedents vary due to wide gaps in their socioeconomic contexts and institutional practices. Among the variables that determine attitude, PU is the most dominant. It implies that students will be more interested in attending online classes if PU is adequately conveyed. This is critically important in the context of Bangladesh and in many other developing countries where students show disinterest in online classes and even put pressure on authorities to open dormitories, defying the requirement of social distancing. The external antecedents also have significant indirect effects on the outcome variable. TC and OCA exert a negative impact on PEU. Thus, students who perceive online classes as complex and suffer from anxiety might have strong negative IOC. This result carries insights for future research on attitude and behavioral intention in a new normal world.

High PEU and PU will reduce resistance from students to online classes and tests. These findings underscore that educational institutions need to interact with students' communities to identify the problems of attending online classes, such as unavailability of devices, weak network speed, electricity failures, and family hardship, so that relevant agencies can design programs for underprivileged students who otherwise might be excluded as a result of the sudden adoption of online classes. Hence, policymakers need to consider the long-lasting effect of regional disparity in terms of access to online education.

Besides, students' AOC will be favorable if their performance expectations are met. If students perceive that their performance will degrade as a result of online classes, their attitude will be negatively affected. TC has the strongest negative effect on PEU, which implies that to increase students' motivation to use an online class, TC needs to be minimized. Academic institutions can organize training programs for students, develop video tutorials that students can access at their convenience, and design an online

LMS. Otherwise, organizing online assessments might go in vain, eventually paralyzing online classes in the new normal.

Limitations and Future Directions

Our study is not without limitations. This study has analyzed behavioral intention rather than actual behavior. Analyzing actual behavior by taking into account students' participation and performance indicators might show a different result from the antecedents of behavioral intention. Future studies can explore this relationship by looking at actual performance data. We have collected data from students attending business school. However, the views of students in other schools and results derived from another unit of analysis in a similar context might be different. Future studies can accommodate students' diversity in terms of their fields of study and levels of study, for example, undergraduate and graduate programs. Fresh insights can also be derived by exploring the intention of students to sit for online assessments that can help academic institutions and policymakers address students' concerns. This will guide the investment decision of the government in allocating funds for developing essential educational infrastructure in a new normal.

References

Abdullah, F., Ward, R., & Ahmed, E. (2016). Investigating the influence of the most commonly used external variables of TAM on students' perceived ease of use (PEOU) and perceived usefulness (PU) of e-portfolios. *Computers in Human Behavior*, *63*(10), 75–90. https://doi.org/10.1016/J.CHB.2016.05.014

Agarwal, R., & Prasad, J. (1998). A conceptual and operational definition of personal innovativeness in the domain of information technology. *Information Systems Research*, *9*(2), 204–215. https://doi.org/10.1287/ISRE.9.2.204

Al-Amin, M., Zubayer, A. Al, Deb, B., & Hasan, M. (2021). Status of tertiary level online class in Bangladesh: Students' response on preparedness, participation and classroom activities. *Heliyon*, *7*(1), Article e05943. https://doi.org/10.1016/J.HELIYON.2021.E05943

Aldás-Manzano, J., Lassala-Navarré, C., Ruiz-Mafé, C., & Sanz-Blas, S. (2009). Key drivers of internet banking services use. *Online Information Review*, *33*(4), 672–695. https://doi.org/10.1108/14684520910985675

Al-Fraihat, D., Joy, M., Masa'deh, R., & Sinclair, J. (2020). Evaluating e-learning systems success: An empirical study. *Computers in Human Behavior*, *102*(1), 67–86. https://doi.org/10.1016/J.CHB.2019.08.004

Anwar, S., Nasrullah, M., & Hosen, M. J. (2020). COVID-19 and Bangladesh: Challenges and how to address them. *Frontiers in Public Health*, *8*(154). https://doi.org/10.3389/fpubh.2020.00154

Bauer, H. H., Reichardt, T., Barnes, S. J., & Neumann, M. M. (2005). Driving consumer acceptance of mobile marketing: A theoretical framework and empirical study. *Journal of Electronic Commerce Research*, *6*(3), 181–192.

Binyamin, S. S., Rutter, M., & Smith, S. (2019). Extending the technology acceptance model to understand students' use of learning management systems in Saudi higher education. *International Journal of Emerging Technologies in Learning*, *14*(3), 4–21. https://doi.org/10.3991/ijet.v14i03.9732

Bodrud-Doza, M., Shammi, M., Bahlman, L., Islam, A. R. M. T., & Rahman, M. M. (2020). Psychosocial and socio-economic crisis in Bangladesh due to COVID-19 pandemic: A perception-based assessment. *Frontiers in Public Health*, *8*(341). https://doi.org/10.3389/FPUBH.2020.00341

Chin, W. W. (2010). How to write up and report PLS analyses. In V. Esposito Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of partial least squares: Concepts, methods and application* (pp. 645–689). Springer.

Chowhan, S., & Ghosh, S. R. (2020). Role of ICT on agriculture and its future scope in Bangladesh. *Journal of Scientific Research and Reports*, *26*(5), 20–35. https://doi.org/10.9734/JSRR/2020/V26I530257

Chuo, Y.-H., Tsai, C.-H., Lan, Y.-L., & Tsai, C.-S. (2011). The effect of organizational support, self-efficacy, and computer anxiety on the usage intention of e-learning system in hospital. *African Journal of Business Management*, *5*(14), 5518–5523. https://academicjournals.org/journal/AJBM/article-full-text-pdf/6048B0822847

Cigdem, H., & Topcu, A. (2015). Predictors of instructors' behavioral intention to use learning management system: A Turkish vocational college example. *Computers in Human Behavior*, *52*(13), 22–28. https://doi.org/10.1016/J.CHB.2015.05.049

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Routledge.

Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., Magni, P., & Lam, S. (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Learning & Teaching*, *3*(1), 1–20. https://doi.org/10.37074/jalt.2020.3.1.7

Daniel, S. J. (2020). Education and the COVID-19 pandemic. *Prospects*, *49*(1–2), 91–96. https://doi.org/10.1007/S11125-020-09464-3

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results* [Doctoral dissertation, Massachusetts Institute of Technology]. DSpace@MIT. http://dspace.mit.edu/handle/1721.1/15192

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–339. https://doi.org/10.2307/249008

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. https://doi.org/10.1177/0047239520934018

Esteban-Millat, I., Martínez-López, F. J., Pujol-Jover, M., Gázquez-Abad, J. C., & Alegret, A. (2018). An extension of the technology acceptance model for online learning environments. *Interactive Learning Environments*, *26*(7), 895–910. https://doi.org/10.1080/10494820.2017.1421560

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Addison-Wesley.

Fishbein, M., & Ajzen, I. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall.

Hair, J. F., Hult, G. T., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Sage.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Hajiyev, J. (2018). Assessing students' attitude and intention to use m-learning in higher education. *Journal of Contemporary Educational Research*, *2*(2), 17–25. https://doi.org/10.26689/jcer.v2i2.317

Hao, Y.-W. (2004). Students' attitudes toward interaction in online learning: Exploring the relationship between attitudes, learning styles, and course satisfaction [Unpublished doctoral dissertation]. The University of Texas at Austin.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/S11747-014-0403-8

Jan, A. U., & Contreras, V. (2016). Success model for knowledge management systems used by doctoral researchers. *Computers in Human Behavior*, *59*(7), 258–264. https://doi.org/10.1016/j.chb.2016.02.011

Kaplan, K. J. (1972). On the ambivalence-indifference problem in attitude theory and measurement: A suggested modification of the semantic differential technique. *Psychological Bulletin*, *77*(5), 361–372. https://doi.org/10.1037/H0032590

Khan, A. H., Sultana, M. S., Hossain, S., Hasan, M. T., Ahmed, H. U., & Sikder, M. T. (2020). The impact of COVID-19 pandemic on mental health & wellbeing among home-quarantined Bangladeshi students: A cross-sectional pilot study. *Journal of Affective Disorders*, *277*(18), 121–128. https://doi.org/10.1016/J.JAD.2020.07.135

Lee, J., Song, H.-D., & Hong, A. J. (2019). Exploring factors, and indicators for measuring students' sustainable engagement in e-learning. *Sustainability*, *11*(4), Article 985. https://doi.org/10.3390/su11040985

Lin, T. T. C., & Bautista, J. R. (2017). Understanding the relationships between mHealth apps' characteristics, trialability, and mHealth literacy. *Journal of Health Communication*, *22*(4), 346–354. https://doi.org/10.1080/10810730.2017.1296508

Liñán, F., & Chen, Y.-W. (2009). Development and cross-cultural application of a specific instrument to measure entrepreneurial intentions. *Entrepreneurship Theory and Practice*, *33*(3), 593–617. https://doi.org/10.1111/J.1540-6520.2009.00318.X

Liu, S.-H., Liao, H.-L., & Pratt, J. A. (2009). Impact of media richness and flow on e-learning technology acceptance. *Computers & Education*, *52*(3), 599–607. https://doi.org/10.1016/J.COMPEDU.2008.11.002

Mailizar, M., Burg, D., & Maulina, S. (2021). Examining university students' behavioural intention to use e-learning during the COVID-19 pandemic: An extended TAM model. *Education and Information Technologies*, *26*, 7057–7077. https://doi.org/10.1007/s10639-021-10557-5

Mannan, A. (2017, February 25). Achieving our higher education targets. *The Daily Star*. https://www.thedailystar.net/education-employment/achieving-our-higher-education-targets-1366513

Murphy, M. P. A. (2020). COVID-19 and emergency eLearning: Consequences of the securitization of higher education for post-pandemic pedagogy. *Contemporary Security Policy*, *41*(3), 492–505. https://doi.org/10.1080/13523260.2020.1761749

Nikou, S. A., & Economides, A. A. (2017). Mobile-based assessment: Investigating the factors that influence behavioral intention to use. *Computers & Education*, *109*(6), 56–73. https://doi.org/10.1016/J.COMPEDU.2017.02.005

Rizun, M., & Strzelecki, A. (2020). Students' acceptance of the COVID-19 impact on shifting higher education to distance learning in Poland. *International Journal of Environmental Research and Public Health*, *17*(18), Article 6468. https://doi.org/10.3390/IJERPH17186468

Saadé, R. G., & AlSharhan, J. (2015). Discovering the motivations of students when using an online learning tool. *Journal of Information Technology Education: Research*, *14*(1), 283–296. http://www.jite.org/documents/Vol14/JITEv14ResearchP283-296Saade1724.pdf

Sánchez, R. A., & Hueros, A. D. (2010). Motivational factors that influence the acceptance of Moodle using TAM. *Computers in Human Behavior*, *26*(6), 1632–1640. https://doi.org/10.1016/J.CHB.2010.06.011

Sarker, M. F. H., Mahmud, R. A., Islam, M. S., & Islam, M. K. (2019). Use of e-learning at higher educational institutions in Bangladesh: Opportunities and challenges. *Journal of Applied Research in Higher Education*, *11*(2), 210–223. https://doi.org/10.1108/JARHE-06-2018-0099

Sarstedt, M., Ringle, C. M., & Hair, J. F. (2017). Partial least squares structural equation modeling. *Handbook of Market Research*, *26*(1), 1–40. https://doi.org/10.1007/978-3-319-05542-8_15-1

Schepers, J., & Wetzels, M. (2007). A meta-analysis of the technology acceptance model: Investigating subjective norm and moderation effects. *Information & Management*, *44*(1), 90–103. https://doi.org/10.1016/J.IM.2006.10.007

Shankar, A., & Datta, B. (2018). Factors affecting mobile payment adoption intention: An Indian perspective. *Global Business Review*, *19*(3), S72–S89. https://doi.org/10.1177/0972150918757870

Sintema, E. J. (2020). Effect of COVID-19 on the performance of grade 12 students: Implications for STEM education. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(7), Article em1851. https://doi.org/10.29333/EJMSTE/7893

Sukendro, S., Habibi, A., Khaeruddin, K., Indrayana, B., Syahruddin, S., Makadada, F. A., & Hakim, H. (2020). Using an extended technology acceptance model to understand students' use of e-learning during Covid-19: Indonesian sport science education context. *Heliyon*, *6*(11), Article e05410. https://doi.org/10.1016/J.HELIYON.2020.E05410

Teo, T. (2009). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education*, *52*(2), 302–312. https://doi.org/10.1016/J.COMPEDU.2008.08.006

Teo, T. (2010). Examining the influence of subjective norm and facilitating conditions on the intention to use technology among pre-service teachers: A structural equation modeling of an extended technology acceptance model. *Asia Pacific Education Review*, *11*(2), 253–262. https://doi.org/10.1007/s12564-009-9066-4

Teo, T. (2012). Examining the intention to use technology among pre-service teachers: An integration of the technology acceptance model and theory of planned behavior. *Interactive Learning Environments*, *20*(1), 3–18. https://doi.org/10.1080/10494821003714632

Teo, T., Zhou, M., Fan, A. C. W., & Huang, F. (2019). Factors that influence university students' intention to use Moodle: A study in Macau. *Educational Technology Research and Development*, *67*(3), 749–766. https://doi.org/10.1007/S11423-019-09650-X

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly*, *15*(1), 125–143. https://doi.org/10.2307/249443

Vanduhe, V. Z., Nat, M., & Hasan, H. F. (2020). Continuance intentions to use gamification for training in higher education: Integrating the technology acceptance model (TAM), social motivation, and task technology fit (TTF). *IEEE Access*, *8*, 21473–21484. https://doi.org/10.1109/ACCESS.2020.2966179

Venkatesh, A., & Edirappuli, S. (2020). Social distancing in Covid-19: What are the mental health implications? *BMJ*, *369*, Article m1379. https://doi.org/10.1136/BMJ.M1379

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, *11*(4), 342–365. https://doi.org/10.1287/ISRE.11.4.342.11872

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273–315. https://doi.org/10.1111/J.1540-5915.2008.00192.X

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425–478. https://doi.org/10.2307/30036540

Wong, K.-T., Russo, S., & McDowall, J. (2013). Understanding early childhood student teachers' acceptance and use of interactive whiteboard. *Campus-Wide Information Systems*, *30*(1), 4–16. https://doi.org/10.1108/10650741311288788

Yang, S., Lu, Y., Gupta, S., Cao, Y., & Zhang, R. (2012). Mobile payment services adoption across time: An empirical study of the effects of behavioral beliefs, social influences, and personal traits. *Computers in Human Behavior*, *28*(1), 129–142. https://doi.org/10.1016/J.CHB.2011.08.019

Yi, M. Y., Fiedler, K. D., & Park, J. S. (2006). Understanding the role of individual innovativeness in the acceptance of IT-based innovations: Comparative analyses of models and measures.

Decision Sciences, *37*(3), 393–426. https://doi.org/10.1111/J.1540-5414.2006.00132.X

Zia, A. (2020). Exploring factors influencing online classes due to social distancing in COVID-19 pandemic: A business students perspective. *The International Journal of Information and Learning Technology*, *37*(4), 197–211. https://doi.org/10.1108/IJILT-05-2020-0089

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A Case Study on How Distance Education May Inform Post-Pandemic University Teaching

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Abstract

Higher education recently found itself in the unprecedented situation of being forced to rapidly switch to online education as a demand of the COVID-19 pandemic. The aim of this article is to compare and contrast the experiences of university tutors who teach in two distance education universities with those who teach in a traditional university concerning their online lessons during lockdown. Forty university tutors participated in a survey to capture their teaching experiences. The survey was based on the transactional distance theory. Both qualitative and quantitative data were collected from both groups. Analysis of the quantitative data indicates no significant differences between the two groups in scores regarding course structure flexibility and the degree of student autonomy; however, significant difference with a high effect size was found regarding instructional dialogue, in favor of the distance tutors' group. Thematically analyzing the qualitative data allowed the researchers to group the data into three main themes focused on how the instructional dialogue was manifested in the classes of both groups: (a) the learning design approach adopted, (b) the tutor-led interaction for student support, and (b) learner-to-learner communication and the sense of an online community. Ensuing recommendations involve adopting social-constructivist approaches that can sustain high-quality instructional dialogue in online learning settings and creating distance education faculty development programs in traditional universities that will help tutors support dialogical forms of online pedagogy.

Keywords: distance education, higher education, emergency remote teaching, transactional distance theory, university tutors' perceptions

A Case Study on How Distance Education May Inform Post-Pandemic University Teaching

To cope with the forced isolation globally experienced during the spring semester of the 2020 academic year due to the COVID-19 pandemic, higher education (HE) moved online. Online courses in most cases adopted a blended learning mode aiming to balance between synchronous and asynchronous learning experiences (Bruff, 2020; Miller, 2020) depending on the university policy, available resources, and faculty's digital literacy (Beaunoyer et al., 2020). This situation affected both distance education (DE) and traditional universities in various ways, although the former were already oriented to distance learning. The term *emergency remote teaching* (ERT) (Hodges et al., 2020) was adopted to underline universities' immediate actions with respect to modifying the teaching aspect, as well as the difference between courses already offered online in a distance learning institutional context and online courses offered as an emergency response to keep the educational process moving at a high-quality level and support the cohesion of the academic community (Bawa, 2020; Hodges et al., 2020; Roberts, 2020). Currently, effort is devoted to analyzing online courses offered due to the COVID-19 pandemic, focusing on the lessons learned from this experience, in order to reconceptualize academic teaching in a way more beneficial for the students and society as a whole (Bawa, 2020; Ferdig et al., 2020).

Those implementing ERT tried to integrate online learning approaches; however, the particular circumstances under which this happened did not allow for the affordances of online learning design to be fully exploited (Means et al., 2014). It is crucial to investigate the key differences between ERT and DE (Bawa, 2020). Many researchers in digital teaching and learning have highlighted that during the pandemic, to a large extent, the concept of DE and its underlying principles were misperceived (Taskiran, 2022). Bozkurt and Sharma (2020) provide some examples of why it is important to know the differences between these two terms. For instance, they argue that "designing learning systems under the wrong assumptions and framing them around wrong definitions will make us more vulnerable to errors along the way" (Bozkurt & Sharma, 2020, p. ii). Also, naming bad implementations of ERT as examples of DE will have a negative and unfair impact to educators' views toward DE, and in that sense, it would undermine the efforts of promoting DE in the educational community that have been taking place for many decades.

The process of moving online was quite stressful for many tutors (Hodges et al., 2020). Wise (2019) found that prior online or face-to-face (f2f) experience does not correlate to tutors' sense of efficacy in enacting meaningful student engagement and learning mastery in the online classroom. Challenges that university faculty had to face include creating content for online classes, learning new tools for developing or delivering content, understanding online pedagogy and media affordances, and attempting various pedagogical strategies to address both synchronous and asynchronous teaching and learning (Hartshorne et al., 2020; Hodges et al., 2020), as well as addressing the communication gap with their students (Karakaya, 2021). In relation to the aspect of faculty professional development, Luongo (2019) suggests programs that provide enhanced opportunities that (a) focus on models for online pedagogy, (b) can assist faculty in practicing DE by identifying and meeting their needs, and (c) cater to course management suitable for DE.

Aiming to contribute to the ongoing dialogue on ERT in the COVID-19 period, we used conceptual tools of distance learning such as Moore's (1993) transactional distance (TD) theory to analyze how this emergency situation was perceived by active university tutors of two DE universities and one traditional university and, additionally, to articulate on the affordances of the DE learning design for promoting more active and student-centered approaches in academic teaching. In particular, the current study focuses on the following research question: Were there any differences between two groups of active university tutors in their perceptions regarding the parameters of TD theory in their online lessons during the COVID-19 emergency situation? If yes, what were these differences, and how were they manifested in their online lessons?

The two groups are university tutors who were working at two European DE universities and university tutors who were working at a European traditional university that had to switch to fully online teaching/learning due to the COVID-19 crisis.

Theoretical Framework

Although it was originally proposed many years ago (Moore, 1993), the TD theory is still considered one of the most influential theories of DE (Paul et al., 2015; Weidlich & Bastiaens, 2018). It reconceptualized the construct of distance in DE by viewing it in learning design terms rather than just in terms of physical separation between the students and the tutor (Paul et al., 2015). Moore views TD as a separation between these two that brings about "a psychological and communications space to be crossed, a space of potential misunderstanding between the inputs of the tutor and those of the learner. It is this psychological and communications space that is the transactional distance" (1993, p. 22). Thus, TD has a negative effect on the teaching–learning process.

In any educational program, TD is bound by three variables (Moore, 1993): course structure, student autonomy, and instructional dialogue. *Structure* expresses the rigidity or the flexibility of educational objectives, teaching strategies, and evaluation methods and the extent to which an education program can accommodate or be responsive to students' individual needs. Structure was operationalized as *learner–content interaction* and *learner–interface interaction* (Benson & Samarawickrema, 2009; Huang et al., 2015, 2016). Processes that can be structured are, among others, presentation of information (e.g., information, recorded media) and stimulation of analysis and criticism, as higher-order thinking skills that university students are expected to develop (e.g., by organizing discussions in a Web conference session in conjunction with a recorded video presentation) (Moore, 1993).

Autonomy denotes the degree of autonomy exercised by the student in the teaching–learning process. It was operationalized as *independence of learning* and *study habits* (Huang et al., 2015, 2016; Macaskill & Taylor, 2010). The former can be further operationalized as responsibility of learning, openness to experience, intrinsic motivation, and self-confidence in new activities. The latter can be further broken down into learning and study practices, reflecting on time management, attitudes to working alone, and procrastination.

Dialogue is developed by students and tutors during their interaction. It can be characterized by its extent (e.g., a frequent basis and through multiple means) and by its quality. The latter is the defining characteristic between dialogue and interaction, since dialogue helps achieving a purposeful, constructive, and valued interaction (Moore, 1993; Huang et al. 2015; 2016). Dialogue has been operationalized as *learner–instructor interaction* and *learner–learner interaction* (Benson & Samarawickrema, 2009; Huang et al., 2015, 2016). Shearer (2009) has suggested a theoretical framework for the dialogue in these two types of interaction that discerns two forms, namely, dialogue toward understanding and dialogue toward conversation. The latter pinpoints to the importance of using educational technologies in DE to support social presence that caters to student motivation and a sense of being there for the learner, whereas the former conveys the idea that the dialogue should support students to achieve the learning objectives and that this is possible via well-orchestrated discussions.

In addition to its three central constructs, some researchers suggest that the teaching *context* should also be considered as a central, constituent component of the TD theory (see, e.g., Benson & Samarawickrema, 2009). Moore (1993) also suggests that dialogue can be dependent on a number of environmental factors, such as the number of students per class, the subject matter, and the academic level. Benson and Samarawickrema (2009) used six cases with different relative levels of structure, autonomy, and dialogue as examples illustrating that the context in which the learning is taking place can affect the patterns of the relationships between the three central constructs of the TD theory and TD itself in the selected learning contexts. This is in contrast with previous ideas suggesting that fixed relationships exist between these three variables.

In terms of pedagogical approaches, Zhang's (2003) empirical research suggests that constructivist and social learning theories, as well as the creation of learning communities, might have a positive effect toward TD, as perceived by students. Consequently, orchestrating a sense of community is the first step a tutor needs to take in an online environment (Naidu, 2018). Literature on TD theory points out the importance of dialogue as a driver of a constructivist DE environment and also a need for guidance on promising strategies for increasing dialogue (Farquhar, 2013). Established by the Institute of Technology at the University of Ontario in Canada, the Fully Online Learning Community (FOLC) is a social-constructivist model for online learning that reduces TD. The FOLC model (Blayone et al., 2017), based on the Community of Inquiry model (Garrison, 2009), emphasizes collaborative learning as "a symbiosis of social and cognitive interactions amplified through effective use of synchronous and asynchronous digital affordances" (Blayone et al., 2017, p. 1), incorporating authentic assessment and recognizing students' contexts and competencies. Finally, Papanikolaou et al. (2017) discuss a blended learning approach enacting social orchestration patterns in order to cultivate the sense of community in a teacher training context.

Relevant Works

To understand better how TD among DE university students affects the DE learning process, Kassandrinou et al. (2014) explore students' perceptions. They conducted a small case study interviewing 12 undergraduate students at the Hellenic Open University and analyzed the results via content analysis. Their main finding is that students perceived TD in terms not only of physical separation, but also of restricted communication and interaction. They also found that the lack of communication among peers has a negative effect, whereas building learning communities among peers can reduce the dropout rate.

Bawa (2020) uses a quantitative approach and an experimental design to understand the effect of ERT on students' grades. In doing so, she defines ERT as "the shift from f2f courses to alternate or online delivery modes, to provide instruction during a crisis situation" (Bawa, 2020, p. 1). The experimental group comprised students who had experienced ERT when their f2f courses moved online during

COVID-19 lockdowns, whereas the control group comprised students who did not experience ERT. Both groups are coming from a US-based university that was not a DE institution before the COVID-19 crisis. Bawa (2020) also collected student perceptions of the ERT using excerpts from course discussion forums and personal communications between faculty and students. The quantitative analysis indicates that student grade performance was not negatively affected when students faced ERT and that the experimental groups who transitioned to ERT performed better than the control group. Yet the students' perceptions of ERT were more negative than positive. The qualitative analysis also revealed that communication is a key factor in making student experience of ERT positive or negative, and it expresses concerns around collaborative and group work.

By conducting interviews, West (2019) explored the experiences of faculty members who were teaching in DE to a diverse student population regarding teaching methods and student–teacher interaction in an ethnographic case study. Regarding the former, the participants reported their experiences on differentiated instruction (e.g., different formats of learning materials to meet the different learning styles), interactive instruction (e.g., using interactive Web 2.0 tools), and collaborative learning activities (e.g., group discussions and case scenarios to enhance student participation). In addition, they mentioned methods that build on students' motivation, support tutor–student communication, or support knowledge retention. Regarding the latter, they focused on the social and teaching presence of the tutor (e.g., interaction through assignments, discussion boards, e-mails, phone calls, and conference calls).

In their study, Kara and Yildirim (2020) aimed to determine best practice faculty behaviors in DE, according to perspectives of different DE stakeholders in Turkey (experts, faculty members, administrators, and students) using the TD theory framework. They collected data from various sources and analyzed them via the constant comparison method. The codes that emerged created themes based on the TD theory. Optimal behaviors critical to dialogue involved student–faculty interaction (establishing human touch, responding timely, providing feedback, providing alternative ways for interaction), student–student interaction (supporting students in discussions, encouraging collaboration), student–content interaction (guiding for learning), and student–interface interaction (providing easy navigation for materials, guiding for instructional tools on the learning management system, facilitating access to materials). Regarding pedagogical practices, they involved appropriate methods (demonstrating effective presentation skills, establishing social interaction with students, paying individual attention to each student, using alternative evaluation methods based on objectives).

Finally, a case of Peking University's online education (Bao, 2020) presents several instructional strategies from current online teaching experiences that were adopted during the COVID-19 emergency situation: (a) high relevance between online learning design and student learning, (b) effective delivery of online learning materials and information, (c) adequate support provided by faculty and teaching assistants to students, (d) high-quality participation to improve the breadth and depth of student's learning, and (e) having a contingency plan to deal with unexpected incidents of online education platforms. The case study does not include a methodology section, thus making the validity of these principles questionable.

Method: Participants, Instrument, Procedure, and Design

Participants in this research were 40 active university tutors, divided into two equal groups (of 20 persons each). The first group comprised tutors working in the DE sector via a formal institutional structure (i.e., working in a DE university), and the second group comprised tutors working at a traditional university who had to move online due to the lockdowns and their university's closure during COVID-19. Typically, each participant was teaching one course or supporting equivalent teaching/learning activities (e.g., supervising of undergraduate students doing their master's thesis and PhD students). Participants were self-selected, since participation in the survey was voluntary. We used maximum variation sampling (Suri, 2011), which is a purposive sampling technique used to capture a wide range of perspectives relating to the research question, with key criteria being the teaching context and the class size. The participants taught in diverse subject matters, ranging from engineering to humanities. In terms of class size, the distance tutors worked with relatively small class sizes (i.e., < 30 students per class), which is typical for DE universities. The second group of participants were more diverse with respect to the teaching context, ranging from a small research team (e.g., in one case involving research supervision of master and PhD students) to a large class of more than 300 students, where a faculty member is typically supported by several teaching assistants. All participants lived and worked in Europe. This kind of variation is referred to as phenomenal variation, according to which researchers working with limited resources can reduce the minimum number of sampling units required in a single research project, but still produce credible and significant findings (Sandelowski, 1995).

The survey was online and anonymous, and it contained three main sections. The first involved basic information about the teaching context, that is, subject matter, class size, and academic levels, in accordance with Moore's (1993) suggestion on what to focus on with respect to the context and environmental variables. The second section involved the three main constituent variables of the TD theory: structure, autonomy, and dialogue. The TD theory was selected by the authors as being one of the most robust and influential theories of DE. The participants were asked to assign scores to their course in each of these three variables using a five-point Likert scale. The survey also provided participants short definitions of the variables in line with Moore's (1993) work. This survey section consisted of answering the "what" dimension of the research question. The third part of the survey involved a small number of open-ended questions. Participants were asked to comment on the previously assigned scores and to briefly describe (a) their role as a tutor during the lockdown, (b) any educational technology tools used, and (c) whether they had to change/adjust their teaching practices during the lockdown and if yes, how.

Triangulation of methods (or mixed methods) was deemed an appropriate approach to study the phenomenon at stake and answer to the research question. *Triangulation*, which herein is defined as "the use of multiple methods mainly qualitative and quantitative methods in studying the same phenomenon for the purpose of increasing study credibility" (Hussein, 2009, p. 1), has been advocated by several social sciences researchers (see, e.g., Altrichter et al., 2018; Heale & Forbes, 2013; Hussein, 2009). It has been suggested that when combined, there is a great possibility of neutralizing the flaws of one method and strengthening the benefits of the other for better research results (Heale & Forbes, 2013; Hussein, 2009). Also, combining qualitative and quantitative methods may provide complementary results highlighting different aspects of the phenomenon (Heale & Forbes, 2013). Consequently, two different methods of data collection and analysis were applied and combined: to answer the first part of the question (the "what" aspect of the studied phenomenon), the participants reflected on and characterized their lessons with respect to the three parameters of the theory of TD using the Likert scale (quantitative data); to get a more detailed picture that would enable us to answer the second part of the question (the "how" aspect), participants completed the open-ended questions prompting them to describe their lessons and teaching experience (qualitative data).

The quantitative data were analyzed using appropriate statistical methods: descriptive statistics and a nonparametric statistical test to measure any difference between the two groups. The Mann–Whitney *U* test was employed as opposed to the independent samples *t*-test because it is similar to the *t*-test and can be used when data do not meet the parametric assumptions of the *t*-test—for example, when the data are not normally distributed. The qualitative data were analyzed using thematic analysis, as described by Braun and Clarke (2012)—that is, by following a six-step process: (a) familiarize oneself with the data, (b) generate initial codes, (c) search for themes, (d) review potential themes, (e) define and name themes, and (f) report results. Two analysts (i.e., the authors) worked in parallel with the tutors' answers to the open-ended questions; they had three online consensus meetings to discuss their understandings with respect to the six-step process and to resolve any differences with respect to the findings of the thematic analysis.

Results

Table 1 shows basic quantitative results (i.e., descriptive statistics) on the scores of the parameters of the TD theory between university tutors who were working in DE and those working in the traditional university.

Table 1

Descriptive Statistics

Parameters	Distance university			Traditional university		
	Median	*M*	*SD*	Median	*M*	*SD*
Structure	4.000	3.700	1.174	3.500	3.400	1.429
Dialogue	5.000	4.500	0.761	4.000	3.800	0.951
Autonomy	4.000	4.050	0.999	5.000	4.600	0.995

Mann–Whitney *U* tests were run to determine if there were significant differences in the scores assigned in the variables structure, autonomy, and dialogue between university tutors in the two groups. Distributions of the scores for the two types of university tutors were similar, as assessed by visual inspection (but they did not follow the normal distribution; thus, the *t*-test was not appropriate). The structure and autonomy scores were not statistically significantly different for the two types of university tutors. The dialogue score was statistically significantly higher in tutors who worked in DE universities than those working in the traditional university (U = 115, z = -2.459, p = .05). The effect size of this result was calculated using Cohen's d. It was found equal to .78, indicating a medium to strong effect size.

Driven by the quantitative results that point to nonsignificant differences with respect to the structure and autonomy scores and to a significant difference with a large effect in the dialogue score, the qualitative analysis was oriented to the "how" aspect of the dialogue phenomenon—that is, how dialogue was manifested in praxis in the online classes of the two groups (including interaction, communication, social learning, etc.). The analysis concluded in three main themes that are presented in detail below: the learning design approach adopted, the tutor role concerning their interaction with students with respect to support offered, and the student perspective—mainly, student-to-student interaction.

"To Lecture or Not to Lecture?": Lecture-Type Approach with Tutor-Led Dialogue Versus Participatory Approaches (Theme 1: Learning Design Approach Adopted)

The first theme maps the focus of the learning design approach adopted in both groups as this mainly affects the flow of interaction and dialogue in the group. Traditional university tutors primarily adopted a lecture-type approach enhanced with tutor-led dialogue, while more participatory approaches were adopted by the DE tutors. For traditional university tutors, a common pattern of dialogue between tutor and students pertains to tutors answering students' questions related to video lecture recordings that students were supposed to watch before the live online session. Tutors' reflections often underlined the focus of the learning design as providing either f2f or recorded lectures and delivering them to students to watch them at their own pace:

> Lectures … were given during the semester.

> We decided to record the teaching content for each session and then upload it couple of days before the session starts.

> I found it crucial that I can meet and work with the students on the tasks given after the video lecture.

The tutors mentioned they then answered students' questions either synchronously or asynchronously:

> During online teaching session time students can ask their questions about the recorded presentation.

> [Using] the university learning management system discussion board. By e-mail, if any problem [occurs] in understanding the concepts of the lectures.

However, the traditional university tutors expressed their disappointment in the level of dialogue and interaction in this learning design, mainly during synchronous meetings:

> Live-digital lecture [using the Web conference system] this semester had resulted in 200 black screens, where nobody dares to speak.

> I did feel quite lonely in the teaching process, and it was odd to sit in "classrooms" where I couldn't see others, and where they wouldn't speak to me.

> Sometimes it felt weird to talk in front of a computer screen without being able to feel the reactions and body language of the students.

> I think the live (synchronous) lectures on the Web conference system leave students quite isolated (unless it's a small class). They tend to speak less than in physical class, hence they appear to be more lonely.

In the case of DE tutors, tutors explicitly mentioned the focus on creating a participatory and social learning environment ("participatory teaching of student-centered philosophy"), indicating that this was an intentional learning design effort: "I was interested in formulating an appropriate learning environment, where everyone feels safe to express themselves and actively participate."

Thus, tutors in DE universities aimed to *increase opportunities for interaction*: "I doubled the number of online meetings and I tried to activate the online forum towards a more participatory process." They also aimed to *promote engagement*, caring for fostering dialogue and participation either during synchronous online meetings or between them:

> I tried to avoid lecture—presentation so that the lesson would become more participatory.

> Combination of lecture, discussion, and brainstorming using tools of the online platform.

> Discussion is the basis of communication during online meetings and between them.

Tutor-Led Interaction for Student Support (Theme 2: Dialogue Toward Understanding)

The DE group tutors intensively supported students, also providing personalized feedback in many cases. In particular, *support and personalized feedback* was regularly offered to students:

> [I have] weekly plenary meetings, plus frequent individual meetings with students.

> The course structure is more flexible regarding the support offered to students which can be also personalized.

The focus was on pacing advice, study support, and feedback on assignments:

> Students' guidance on their assignments, feedback, study guidance and counselling.

> [I have] frequent communication with students on the assignments' topics and course content.

> The three assignments that students submit were initially on the same topic which they transformed in successive versions due to my feedback on each particular version.

Even the telephone and their personal phone number were used as a means of communication: A participant mentioned they used "telephone-based communication once a week."

On the other hand, support provided by traditional university tutors was mainly taking place during synchronous sessions, where students could pose questions or work together on specific tasks:

> I found it crucial that I can meet and work with the students on the tasks given after the video lecture.
>
> I felt I was closer to the students because of the possibility of anonymous interaction in the live Web conference system.
>
> [I] spend most of the time in the class on problem solving.

Much effort was put by the traditional university tutors in preparing content and recording lectures, that is, in communication-free tasks:

> What I did and also in the meeting with my colleagues, we decided to record the teaching content for each session and then upload it.
>
> I was able to capture 85%–90% of the content before lockdown.
>
> I decided to record the lectures and upload the videos.
>
> We made tests with more than 2,000 pictures and 200 videos.

In a few cases, asynchronous support offered by the traditional university tutors aimed at increasing engagement and interest:

> As a teaser we also used Facebook and Instagram to promote interest.
>
> [I] tried to be more flexible in my communication with them, through personalized e-mails and questions about their well-being.

What About Learner-to-Learner Communication? Emphasis on Community and Collaborative Learning Versus Tutor-Led Communication (Theme 3: Dialogue Toward Understanding and Conversation)

DE tutors adopted a student-centered learning design approach that emphasized *learner-to-learner communication*. One way they did this was by promoting a sense of community:

> I believe that the development of a network among the students works very well.
>
> This process helped me to organize better the communication and the peer support processes in my group by adopting a learning community form.
>
> We had the chance to discuss our assignments, to listen what other students were working on. (student excerpt from participant tutor)

Another way was through collaborative learning approaches:

> Moreover, I think it is important to propose them studying strategies (mainly collaborative).

> I insisted particularly in creating groups (freely organized) out of the formal university context.

> The students' deliverables were the two group assignments.

A DE tutor noted that training is necessary to effectively apply collaborative learning in online learning settings, however:

> Migrating an f2f collaborative learning approach into an online environment was a difficult task. There is a training need for effectively moving collaborative approaches online.

In the case of the traditional university tutors, learner-to-learner communication does not appear as a goal in itself. However, there are cases in which learner–learner collaboration is a demand of a course's main project:

> Students work in groups to develop a software product through a software engineering process.

> For the last five days the teaching context changed drastically as the groups became remote collaborators and we had to meet in the digital classroom.

In the last quote, the teaching context refers to a flagship course titled "Experts in teams", a course that aims to help students developing their interdisciplinary teamwork skills.

Learner–learner collaboration also came up as a learning design decision:

> In the research methods course I arranged a total of five asynchronous learning activities: [for example,] … comment on classmates' reflective texts.

> Learning activities in plenum, exercises in the groups and work on the group projects.

> Group work took place in break-out rooms on [one of the Web conference systems offered by the university].

Discussion and Conclusions

The aim of the study was to contribute to the ongoing discussion about better understanding of what happened to teaching and learning in HE as a result of universities' sudden shift to online education during the COVID-19 pandemic and the ensuing ERT. To that end, this case study conducted a comparison between 20 tutors working in two DE universities and 20 tutors working in a traditional university (all of them European). The rationale is that DE is a long-established scientific field and DE universities have a much longer tradition in providing it than traditional universities. ERT and DE are distinctively different, yet they are frequently perceived as similar (Bawa, 2020). It is crucial to investigate the key differences between ERT and DE (Bawa, 2020), and this case study focused on empirical research by comparing and contrasting the perceptions of the two groups of participant tutors regarding the classes that they offered during the pandemic. The research design was guided by the TD theoretical framework originally proposed by Moore (1993), a seminal and robust framework of DE. Consequently, the research work focused on three parameters—course structure, student autonomy, and instructional dialogue—as these are defined and operationalized by the analytical lens of the theoretical framework used.

Methodologically, the research work used a triangulation of methods combining quantitative and qualitative data. The results of the quantitative analysis indicate that the scores that the tutors of the two groups assigned on the course structure and student autonomy variables were not statistically different. Yet, there appears to be significant statistical difference with high effect size on the dialogue variable between the two groups. Qualitative analysis of the tutors' comments on open-ended questions resulted in three themes around instructional dialogue: (a) lecture-type approach with tutor-led dialogue versus participatory learning approaches, (b) differences in tutor-led interaction for student support, and (c) emphasis on community and collaborative learning versus tutor-led communication.

The ensuing results have both research and practical implications. The research implications touch upon the need to examine the key differences between ERT and DE (Bawa, 2020), as well as DE learning design approaches that may be used to address the communication gap between tutors and students in an ERT setting (Karakaya, 2021). Currently, limited research has been done on this. We can separate similar works mentioned in the relevant works section into two main categories: those conducted before the beginning of pandemic when ERT was not a usual situation (if it even existed), and those conducted after (starting in 2020). In the first category, West (2019) observes that the participant DE tutors adopted participatory learning approaches and emphasized community learning. In this line of research, Kassandrinou et al. (2014) emphasize that building learning communities among DE students can reduce dropout rates. In the second category, Kara and Yildirim (2020) report similar results with respect to DE tutors' behaviors, where tutors facilitated various student-centered interactions between the student and faculty members, peers, the learning content, and the interface of the learning technologies used. The authors consider establishing social interaction among students as best pedagogical practice. Bao (2020) presents several instructional strategies of current online teaching experiences that were adopted during the COVID-19 emergency situation. Bawa (2020) finds that although ERT didn't negatively affect students' grades, students' perceptions were more negative than positive, with communication being a key factor. However, the control group in Bawa's (2020) study consists of students who took the same f2f course in previous academic years. In the research conducted herein, we adopt an experimental approach by comparing and contrasting two groups of university tutors, both teaching at a distance, one of them in DE universities and the other in a traditional university. This approach is unique, and furthermore, its methodology could entail less conceptual and design bias.

Additionally, we have shed light on the various aspects of instructional dialogue by comparing how it manifested in praxis in the online classes of both groups in terms of the learning design adopted, the tutor role in interacting with students, and student-to-student interactions. Thus, the results of this research go beyond exploring either DE or ERT, elaborating on the different approaches that they adopt on various aspects of instructional dialogue. All in all, the research works mentioned above as the most similar to the present research arrive at conclusions similar to ours with respect to the importance of facilitating the social aspect in DE settings. However, none of these studies has examined the different aspects of instructional dialogue, comparing the approaches adopted in DE with ERT.

DE is multifaceted and time-consuming in regard to the necessary analysis, design, development, and enactment of courses. Thus, it needs meticulous planning, development, and evaluation (Karakaya, 2021). In contrast, ERT is based on the need to shift to alternative learning solutions until the crisis is over, and it uses practices and features of f2f teaching, but modifies them (Karakaya, 2021). In the study herein, the instructional dialogue appeared to be an issue that did not work well in ERT compared with the typical DE setting. This is important since it is known from previous literature that communication, collaboration, and dialogue in online learning are essential for a quality teaching and learning experience. Conveyed is the idea that the use of learning technology should be examined on the grounds of the pedagogical necessity and integrated into suitable pedagogical models, as well as that technology is actually innovating the learning process and not just technologizing it (Baneres et al., 2019). Consequently, an emerging recommendation herein is the use of social-constructivist pedagogical models, in line with previous suggestions on DE in relation to TD, for example, by Zhang (2003).

The findings also have practical implications for faculty professional development. In particular, the need to offer enhanced opportunities that focus on online teaching pedagogy and course management is highlighted (Luongo, 2019). An ensuing recommendation is to focus on the creation of faculty professional development programs that provide support to traditional university tutors who wish to embark on DE with respect to dialogic forms of online pedagogy. Farquhar (2013) also supports dialogue as a driver of a constructivist DE environment, as well as the need for guidance on promising strategies for increasing it. Furthermore, we need to provide support for both types of dialogue, that is, for dialogue towards understanding but, most importantly, for dialogue towards conversation (Shearer, 2009). With respect to sustaining a high-quality instructional dialogue in a DE setting, the results indicate that suitable instructional strategies are those that help university tutors to make better use of the affordances of the learning technologies in tandem with the affordances of online learning design. In particular, those strategies are the following: (a) embrace participatory approaches with increased opportunities for interaction, (b) create a social learning environment that promotes engagement, (c) provide support and personalized feedback, and (d) cater to learner-to-learner communication (in addition to tutor-to-learner communication) and collaboration.

Finally, designing a course suitable for high-quality DE is a time-consuming, multifaceted, and interactive learning design process (Bawa, 2020; Luongo, 2019). Therefore, the universities and their leadership need to provide more incentives to faculty members who wish to embark on it (Luongo, 2019). With respect to the human resources needed, the two groups of tutors (i.e. traditional university tutors and DE university) are comparable, since in the case of big classes in the traditional university included in the empirical study, the teaching team was made by the course responsible and several teaching assistants, where typically a teaching assistant is responsible for fewer than 30 students (also true in the typical case of the two DE institutions). This creates, in turn, the implication of extending faculty development programs to teaching assistants, wherever possible, since they are closer to the students in larger classes.

One limitation of this work is the small sample size; in addition, participants are self-selected. According to Moore (1993), context variables (such as the class size, the subject matter, and the academic level of the course), could affect the instructional dialogue. In this study, while there was a wide range of subject matters and academic levels taught by the participant tutors in both groups, the number of students per class in the case of DE is relatively small—this is typical for DE settings. In addition, the data presented are from self-reported scores and perceptions; observations would help provide a more holistic and objective view. Still, this does not affect the research question, but instead it provides directions for possible future research.

References

Altrichter, H., Feldman, A., Posch, P., & Somekh, B. (2018). *Teachers investigate their work: An introduction to action research across the professions* (3rd ed.). Routledge. https://doi.org/10.4324/9781315398822

Baneres, D., Whitelock, D., Ras, E., Karadeniz, A., Guerrero-Roldán, A. E, & Rodríguez, M. E. (2019). Editorial: Technology enhanced learning or learning driven by technology? *International Journal of Educational Technology in Higher Education*, *16*. https://educationaltechnologyjournal.springeropen.com/articles/collections/telleteditorial

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies*, *2*(2), 113–115. https://doi.org/10.1002/hbe2.191

Bawa, P. (2020). Learning in the age of SARS-COV-2: A quantitative study of learners' performance in the age of emergency remote teaching. *Computers and Education Open*, *1*, Article 100016. https://doi.org/10.1016/j.caeo.2020.100016

Beaunoyer, E., Dupéré, S., & Guitton, M. J. (2020), COVID-19 and digital inequalities: Reciprocal impacts and mitigation strategies, *Computers in Human Behavior*, *111*, Article 106424. https://doi.org/10.1016/j.chb.2020.106424

Benson, R., & Samarawickrema, G. (2009). Addressing the context of e-learning: Using transactional distance theory to inform design. *Distance Education*, *30*(1), 5–21. https://doi.org/10.1080/01587910902845972

Blayone, T. J., Barber, W., DiGiuseppe, M., & Childs, E. (2017). Democratizing digital learning: Theorizing the fully online learning community model. *International Journal of Educational Technology in Higher Education*, *14*(1), 1–16. https://doi.org/10.1186/s41239-017-0051-4

Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to coronavirus pandemic. *Asian Journal of Distance Education*, *15*(1), i–vi. http://www.asianjde.com/ojs/index.php/AsianJDE/article/view/447

Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology: Research designs: Quantitative, qualitative, neuropsychological, and biological* (Vol. 2, pp. 57–71). American Psychological Association. https://doi.org/10.1037/13620-004

Bruff, D. (2020, 7 March). *Resources for just-in-time online teaching*. Vanderbilt Center for Teaching. https://cft.vanderbilt.edu/2020/03/resources-for-just-in-time-online-teaching/

Farquhar, L. (2013). The intersection of dialogue and low transactional distance: Considerations for higher education. *European Journal of Open, Distance and E-Learning*, *16*(2), 28–39. https://files.eric.ed.gov/fulltext/EJ1017524.pdf

Ferdig, R. E., Baumgartner, E., Hartshorne, R., Kaplan-Rakowski, R., & Mouza, C. (Eds.). (2020). *Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the field*. Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/p/216903/

Garrison, D. R. (2009). Communities of inquiry in online learning. In P. L. Rogers, G. A. Berg, J. V. Boettcher, C. Howard, L. Justice, & K. D. Schenk (Eds.), *Encyclopedia of distance learning* (2nd ed., pp. 352–355). IGI Global. https://doi.org/10.4018/978-1-60566-198-8.ch052

Hartshorne, R., Baumgartner, E., Kaplan-Rakowski, R., Mouza, C., & Ferdig, R. E. (2020). Special issue editorial: Preservice and inservice professional development during the COVID-19 pandemic. *Journal of Technology and Teacher Education*, *28*(2), 137–147. https://www.learntechlib.org/primary/p/216910/

Heale, R., & Forbes, D. (2013). Understanding triangulation in research. *Evidence-Based Nursing*, *16*(4), Article 98. https://doi.org/10.1136/eb-2013-101494

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020, March 27). The difference between emergency remote teaching and online learning. *Educause Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Huang, X., Chandra, A., DePaolo, C., Cribbs, J., & Simmons, L. (2015). Measuring transactional distance in Web-based learning environments: An initial instrument development. *Open Learning: The Journal of Open, Distance and e-Learning*, *30*(2), 106–126. https://doi.org/10.1080/02680513.2015.1065720

Huang, X., Chandra, A., DePaolo, C. A., & Simmons, L. L. (2016). Understanding transactional distance in Web-based learning environments: An empirical study. *British Journal of Educational Technology*, *47*(4), 734–747. https://doi.org/10.1111/bjet.12263

Hussein, A. (2009). The use of triangulation in social sciences research: Can qualitative and quantitative methods be combined? *Journal of Comparative Social Work*, *4*(1), 106–117. https://doi.org/10.31265/jcsw.v4i1.48

Kara, M., & Yildirim, Z. (2020). Identification of the optimal faculty behaviors for performance improvement in distance education. *Asia Pacific Education Review*, *21*(1), 83–97. https://doi.org/10.1007/s12564-019-09610-3

Karakaya, K. (2021). Design considerations in emergency remote teaching during the COVID-19 pandemic: A human-centered approach. *Educational Technology Research and Development*, *69*, 295–299. https://doi.org/10.1007/s11423-020-09884-0

Kassandrinou, A., Angelaki, C., & Mavroidis, I. (2014). Transactional distance among open university students: How does it affect the learning process? *European Journal of Open, Distance and E-Learning*, *17*(1), 26–42. https://doi.org/10.2478/eurodl-2014-0002

Luongo, N. (2019). Promoting digital teaching and learning: Faculty development options for distance learning instructors. In A. Elçi, L. L. Beith, & A. Elçi (Eds.), *Handbook of research on faculty development for digital teaching and learning* (pp. 56–76). IGI Global. https://doi.org/10.4018/978-1-5225-8476-6.ch004

Macaskill, A., & Taylor, E. (2010). The development of a brief measure of learner autonomy in university students. *Studies in Higher Education*, *35*(3), 351–359. https://doi.org/10.1080/03075070903502703

Means, B., Bakia, M., & Murphy, R. (2014). *Learning online: What research tells us about whether, when and how*. Routledge. https://doi.org/10.4324/9780203095959

Miller, M. D. (2020, 9 March). Going online in a hurry: What to do and where to start. *The Chronicle of Higher Education*. https://www.chronicle.com/article/going-online-in-a-hurry-what-to-do-and-where-to-start/

Moore, M. (1993). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 22–38). Routledge. https://doi.org/10.4324/9780203983065

Naidu, S. (2018). Editorial: To interact or not to interact is NOT the question! *Distance Education*, *39*(3), 277–280. https://doi.org/10.1080/01587919.2018.1483715

Papanikolaou, K., Makri, K., & Roussos, P. (2017). Learning design as a vehicle for developing TPACK in blended teacher training on technology enhanced learning. *International Journal of Educational Technology in Higher Education*, *14*, Article 34. https://doi.org/10.1186/s41239-017-0072-z

Paul, R. C., Swart, W., Zhang, A. M., & MacLeod, K. R. (2015). Revisiting Zhang's scale of transactional distance: Refinement and validation using structural equation modeling. *Distance Education*, *36*(3), 364–382. https://doi.org/10.1080/01587919.2015.1081741

Roberts, L. M. (2020, 28 July). *Trauma-informed teaching during COVID-19*. Vanderbilt Center for Teaching. https://cft.vanderbilt.edu/2020/07/trauma-informed-teaching-during-covid-19/

Sandelowski M. (1995). Sample size in qualitative research. *Research in Nursing and Health*, *18*(2), 179–83. https://doi.org/10.1002/nur.4770180211

Shearer, R. (2009). *Transactional distance and dialogue: An exploratory study to refine the theoretical construct of dialogue in online learning* (Publication no. 3399706) [Doctoral dissertation, Pennsylvania State University]. ProQuest Dissertations Publishing. https://www.proquest.com/docview/304983940

Suri, H. (2011). Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal*, *11*(2), 63–75. https://doi.org/10.3316/QRJ1102063

Taskiran, A. (2022). Effective, efficient, and attractive instructional design for online learning. In G. Durak & S. Çankaya (Eds.), *Handbook of research on managing and designing online courses in synchronous and asynchronous environments* (pp. 140–158). IGI Global. https://doi.org/10.4018/978-1-7998-8701-0.ch007

Weidlich, J., & Bastiaens, T. J. (2018). Technology matters—The impact of transactional distance on satisfaction in online distance learning. *The International Review of Research in Open and Distributed Learning*, *19*(3). https://doi.org/10.19173/irrodl.v19i3.3417

West, T. (2019). *Exploring experiences of diverse faculty with diverse students in distance education* (Publication no. 206) [Doctoral dissertation, Nova Southeastern University]. NSUWorks Digital Library. https://nsuworks.nova.edu/fse_etd/206

Wise, S. R. (2019). *A quantitative correlational study of faculty sense of efficacy in online introductory courses* (Publication no. 3399706) [Doctoral dissertation, Grand Canyon University]. ProQuest Dissertations Publishing. https://www.proquest.com/docview/2307477703

Zhang, A. (2003). *Transactional distance in Web-based college learning environments: Toward measurement and theory construction* (Publication no. 3082019) [Doctoral dissertation, Virginia Commonwealth University]. ProQuest Dissertations Publishing. https://www.proquest.com/docview/305222372

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Development of the Online Course Overload Indicator and the Student Mental Fatigue Survey

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Abstract

The purpose of this study is to develop and examine the psychometric properties of the Online Course Overload Indicator (OCOI) and the Student Mental Fatigue Survey (SMFS). The OCOI was designed to measure students' perceptions of cognitive overload in online courses. The SMFS was used to assess students' perceptions of mental fatigue while taking online courses. An exploratory factor analysis was conducted on a sample of 378 undergraduate students from various institutions offering online courses across the United States. Results of a factor and reliability analyses confirmed that the instruments are valid and reliable measures of students' perceived mental fatigue and overload from online course elements. The analysis supported the model that students' perceptions of overload in online courses consist of four constructs—information relevance, information overload, course design, and facilitation—in addition to the one-factor structure of the SMFS, which consists of the student mental fatigue construct.

Keywords: mental fatigue, cognitive overload, online learning, online course design, student support, online course development

Development of the Online Course Overload Indicator and the Student Mental Fatigue Survey

Mental fatigue is not a novel concept and is one that has received attention through empirical studies in various areas, such as military, aviation, driving, health care, and its effects on shift workers (Ackerman, 2011). Numerous research studies have been conducted on the effects of mental fatigue on employees in work-related environments and clinical settings (e.g., Al Ma'mari et al., 2020; Sarkar & Parnin, 2017). Researchers have also reported on mental fatigue in children and adolescents (Mizuno et al., 2011; Palmer, 2013). It has typically been a problem in clinical and workplace settings. However, limited published research exists on mental fatigue in online course design and its effects on students' cognitive functioning.

With the growth in online courses and programs, students are spending more and more time doing coursework and learning online, and their cognitive functions may be overtaxed to the extent of experiencing mental fatigue. Researchers have found that mental fatigue can play a part in the disruption of cognitive functioning (Boksem & Tops, 2008) and information processing, causing reduced attention and lack of focus on the task (van der Linden, 2011). The effects of mental fatigue may be attributed to factors in the online environment that are beyond students' control, such as information overload, poor course design, and a lack of instructor facilitation, to name a few. Such factors would need further examination to better understand their effects on students' level of mental fatigue in the online environment.

Mental Fatigue

Mental fatigue, sometimes referred to as cognitive fatigue or brain fatigue, is one type of fatigue that is often researched from a performance and motivation perspective. Beiske and Svensson (2010) define mental fatigue as measuring "the subjective feeling of being mentally exhausted, encompassing items such as concentration, memory and speech" (p. 78). DeLuca (2005) describes mental fatigue as "a decrement in performance from excess mental effort" (p. 8). Hockey (2013) refers to it as "an unfocused mental state (distraction, frustration, discomfort)" (p. 1). Boksem et al. (2005) describe mental fatigue as "the effects that people may experience after or during prolonged periods of cognitive activity" (p. 107). The common element in these definitions points to the underlying cognitive processes that are affected by the phenomenon of mental fatigue.

Mental Fatigue and Cognitive Load

The theoretical framework that guides and supports this study is cognitive load theory (CLT) (Plass et al., 2010). CLT is based on the premise that working memory has limited capacity and learners can only process small amounts of information at any one time (Miller, 1994). Consequently, some instructional design practices or strategies can impose extra or unnecessary mental effort and may contribute to mental fatigue that can constrain learning and performance (Clark & Mayer, 2016). Mental load is the load imposed by the task or sequence of information in the instruction (Sweller et al., 1998). Mental effort is the amount of capacity allocated to the demands imposed by the instruction (Sweller et al., 1998). Together, mental load and mental effort make up cognitive load (Ayres, 2006). Cognitive overload occurs when the mental load exceeds mental capacity (Clark & Mayer, 2016). Cognitive overload is certainly not mental fatigue, but it is a trigger that can cause mental fatigue. In other words, once mental capacity is exceeded, the brain becomes mentally exhausted. Individuals typically experience an overload of mental capacity during and after taxing cognitive activity for prolonged periods. Once mental capacity is exceeded, it causes cognitive overload, which can trigger mental fatigue. When students are fatigued, they become disengaged, frustrated, and stressed, and their learning ability and/or capacity becomes diminished.

Online Versus Traditional Classroom Environments

There have been many studies on mental fatigue in work-related and clinical settings, however only a few studies have examined mental fatigue in educational settings (Csathó et al., 2012; Mizuno et al., 2011). This phenomenon has been largely overlooked in online environments, and there have been only a limited number of studies on information overload and fatigue in online environments (Lee et al., 2016; Tugtekin, 2022). However, researchers have found that there are challenges in online environments that might not exist in traditional classrooms, such as student perceptions of isolation; learner frustration, anxiety, and confusion; lack of community; lack of instructor engagement and immediate response; information overload; and challenges with technology, including access to a reliable Internet connection (Holmes & Reid, 2017). These challenges may affect the learner and the online learning experience and could be indicators that the online environment is causing undue mental fatigue.

Sources of Mental Fatigue

Cognitive overload caused by greater mental effort, task difficulty, and design of instruction (Plass et al., 2010) is a contributor to increased levels of mental fatigue (Balkin & Wesensten, 2011). Hence, factors that directly impact students, including course design, facilitation, information overload, and information relevance, are considered potential sources of mental fatigue. The following sections discuss each one of these sources as it relates to the online learning context.

Course Design

Course design is operationalized in this study as the organization, format, and structure of the online course including the components that make up its structure (e.g., multimedia elements, visual design elements, organization, etc.). Clark and Mayer (2016) propose a set of multimedia principles that can be used in the design of online courses to avoid overloading learners with extraneous content and to design courses in effective ways to promote student learning (Clark & Mayer, 2016). Additionally, the organization of the online platform and effective design of learning materials for online courses can help students engage in active learning by decreasing cognitive load. The psychological reason for effective course design is to help learners use their cognitive capacity to focus on the relevant instructional goals by reducing irrelevant processing of information, thereby minimizing cognitive load and mental fatigue.

Facilitation

Facilitation is operationalized in this study as the level of instructor presence, instructor immediacy, and feedback provided in an online course. Facilitation in the online environment is a fundamental element for student learning, satisfaction, and cognitive overload (Wanstreet, 2006). Some researchers have argued that instructor facilitation is important to "support and enhance social and cognitive presence for the purpose of realizing educational outcomes" (Garrison et al., 1999, p. 90). Researchers also note that various forms of instructor behaviors, such as frequently interacting with students, using informality and casualness, returning phone/e-mail messages, and being accessible to students, to name a few (see O'Sullivan et al., 2004, for more cues), can be incorporated via the course design and written interactions (Baker, 2010).

Information Overload

The meaning of information overload can be different depending on the research context. This study adopted the definition proposed by Lee et al. (2016): information overload occurs when individuals "are exposed to more information than they can accommodate in their capacity for information processing" (p. 53). Two main determinants of information overload are human processing capacity and complexity (Sweller, 2008). Plass et al. (2010) declare that the source of cognitive load comes from the design of the materials, the difficulty of the material to be learned, and the mental effort required to process the new information. Furthermore, the type of cognitive load (i.e., intrinsic or extraneous) can contribute to increased levels of mental fatigue, with more difficult tasks consuming more mental effort (Balkin & Wesensten, 2011). Similarly, information overload in the online learning environment can originate from various sources, such as complex course content, an excessive number of readings, numerous topics in one lesson, long videos, and too many resources in the course, to list a few (Guo et al., 2014).

Information Relevance

Information relevance is an important aspect of any course. Roberson (2013) defines relevance as "the perception that something is interesting and worth knowing" (p. 18). Information relevance is operationalized in this study as the extent to which course content is helpful and relevant to a student's learning and success in and outside of the online course (Lee et al., 2016). Information relevance can produce an increase in motivation (Keller, 1983) and a decrease in mental load (Roelle et al., 2015). The irrelevance of information for current or future needs can affect personal motives, goals, and values and lead to greater fatigue due to a lack of motivation (Edwards & Cooper, 2013; Herlambang et al., 2019). Based on research findings, Roelle et al. (2015) conclude that specific relevance instructions could lower the amount of extraneous cognitive load that students have to process, finding that students who received specific relevance instruction had more working memory capacity to execute cognitive processes.

Purpose of the Study

Although the importance of understanding fatigue in learning has been recognized in previous research (Palmer, 2013), no attempt to date has been made to create and validate instruments to measure the underlying concept of student mental fatigue in educational settings (Hafezi et al., 2010). Some previous studies have used self-developed items; for example, Csathó et al. (2012) used a non-standard, one-item statement focusing on student tiredness levels to measure undergraduate and postgraduate students' levels of subjective fatigue before and after fatigue-inducing mental tasks. Others have attempted to use instruments designed for medical purposes. For example, Mizuno et al. (2011) examined cognitive predictors of fatigue in elementary and junior high school students by using the Chalder Fatigue Scale (Chalder et al., 1993), which is designed to measure the severity of chronic tiredness due to illnesses. Another instrument to measure chronic fatigue, the Checklist Individual Strength questionnaire (Vercoulen et al., 1994), has also been frequently used in studies (Bakker et al., 2009). Unfortunately, these existing instruments, usually designed for medical diagnosis purposes, do not specifically measure how fatigued students feel while doing coursework and do not apply to diverse student populations in online courses.

Furthermore, there is no systematic way, at the time of writing, to help instructors identify specific areas in the online environment that may be causing overload. The repercussions could include poorly designed online courses that lead to student cognitive overload, disengagement, and attrition. The challenge presented to online instructors is recognizing whether online instruction and/or the design of the online environment contributes to mental fatigue. As a result, instruments are needed in the field of education to gather information about sources of student mental fatigue in online courses. Understanding these constructs will enable better decision making that can lead to improved instructional design that minimizes cognitive overload and mental fatigue.

Therefore, the purpose of this study was to develop two instruments—the Online Course Overload Indicator (OCOI) and the Student Mental Fatigue Survey (SMFS). The SMFS examines and confirms the level of mental fatigue students are experiencing while doing coursework, and the OCOI helps to identify where the mental fatigue/overload is coming from within the online environment (i.e., online course design elements). The research question of the study is the following: What are the psychometric properties (i.e., factors to be retained, variance for each factor, reliability of subscales, and interpretation of factors) of the OCOI and SMFS?

Methodology

Participants

This study used a non-probability sample from a Qualtrics panel. The target population was undergraduate students who were at least 18 years of age and currently enrolled in a fully online course, defined by the Online Learning Consortium as a course in which all activities are done online without any required face-to-face components (Mayadas et al., 2015). The instruments were administered to students after the Thanksgiving break to ensure that students had enough time to acclimate to the online course and environment. Participants were instructed to complete the survey with respect to any online course they were taking that semester. The panel sample was acquired from Qualtrics Panels, LLC. The company collected data from participants enrolled in various distance education institutions/programs across the United States. The company was responsible for sending the survey out through its panel partners to participants, inviting them to complete the online survey in return for incentives, which the company provided. Nunnally's (1978) widely cited recommendation is that the subject-to-item ratio should be at least 10:1 for exploratory factor analysis. Therefore, the instruments were tested with a large sample to establish validity and reliability (DeVellis, 2003).

Data from 378 undergraduate students, who were enrolled in online courses, were used for the analyses in this study. The majority of students were female (82%; 18% male), which could be due to the trend of higher female enrollment in distance education (Guramatunhu, 2015). The students ranged in age from 18 to 50 years (*M* = 27.15, *Mdn* = 25.00, *SD* = 7.57). The ethnic composition of the sample was diverse. Students self-identified with the following ethnicities: white (65.87%), Black/African American (15.87%), Hispanic/Latino (11.11%), Asian (3.17%), multiple (1.85%), American Indian/Alaskan Native (1.32%), and other (0.79%). Most students indicated that this was not their first semester taking an online course (69.3%). In addition, the data revealed that a large portion of students (62.9%) were taking three to six credit hours of online courses. Regarding technical skills, the majority of the students indicated that they were very proficient computer users (70.9%).

Instrument Design and Development

This section addresses the design and development of the OCOI and the SMFS. This study's inventory design and development process generally followed DeVellis's (2003) eight-step scale development process. Under DeVellis's (2003) guidelines, the eight-step process was organized into three distinct stages for this study: stage 1—identification of constructs and development of subscale items (steps 1–3); stage 2—expert review and validation (steps 4–6); and stage 3—factor analysis and scale optimization (steps 7–8).

Stage 1: Identification of Constructs and Development of Subscale Items

In stage 1, the initial identification of the constructs was based on themes that emerged from an extensive literature review and additional findings in a pilot study, conducted at a four-year public university in the southwestern region of the United States to gather data about the levels of subjective fatigue experienced by online students (Alleyne Bayne, 2016). The pilot study included 63 graduate and undergraduate students from different majors in fully online courses. Results revealed that 36.5% of students had severe levels of mental fatigue, 31.7% had elevated levels, and 31.7% had normal levels (Alleyne Bayne, 2016). Anecdotal evidence from students about the effort exerted were testimonials of their levels of frustration, which were similar to student comments from previous surveys (Barnard & Paton, 2007; Lambert et al., 2009). Several themes emerged from the analysis including information relevance, information overload, course design, instructional activities and materials, and student mental fatigue (Alleyne Bayne, 2016). A list of constructs and their definitions are listed in Table 1.

Table 1

Definition of Constructs

Construct	Definition
Information relevance	The extent to which course content is helpful and relevant to a student's learning and success in and outside of the online course (Lee et al., 2016)
Information overload	Occurs when individuals "are exposed to more information than they can accommodate in their capacity for information processing" (Lee et al., 2016, p. 53)
Course design	The organization, format, and structure of the online course, including the components that make up the structure (e.g., multimedia elements, design elements, etc.)
Instructional activities and materials	The activities and materials that effectively communicate the content and/or instructor's intent (e.g., instructions/guidelines, assignments, reading materials, multimedia elements) to learners to promote learning
Facilitation	The level of instructor presence, instructor immediacy, and feedback provided in an online course
Mental fatigue	A self-reported feeling of tiredness after a long duration of mental activity; encompasses feelings of anxiety, frustration, and stress

The next step was the exploration of relevant literature on existing validated instruments pertinent to the constructs that were investigated, including mental fatigue (Mota & Pimenta, 2006; Vercoulen et al., 1994), information relevance (Lee et al., 2016), information overload (Chen et al., 2011; Lee et al., 2016), student perceptions of connectedness (Bolliger & Inan, 2012), student perceptions and expectations of online learning (Harris et al., 2011), instructional activities and materials (Roach & Lemasters, 2006), facilitation (Bolliger & Inan, 2012; Harris et al., 2011), and course design (Harris et al., 2011). The creation of the initial item pool was guided by the construct definitions provided in Table 1, keywords that represent the constructs, and an existing set of items from other validated instruments.

Stage 2: Expert Review and Validation

In stage 2, the items were written to represent each construct of interest using the guidelines presented by Worthington and Whittaker (2006) for the generation of an item pool—that is, they are "clear, concise, readable, distinct, and reflect the scale's purpose" (p. 813). Decisions were made on the number of items for each scale and the type of response format. Hinkin et al. (1997) recommends four to six items for each construct. The Likert response format was used because it is reported as the most widely used in instrument development for attributes measuring constructs that are unobservable such as attitudes or beliefs (DeVellis, 2003). A preliminary list of 38 items (30 for the OCOI and 8 for the SMFS) on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) was developed.

The item inventory was sent to a panel of experts in distance education and instructional technology for face and content validity evaluation. The panel experts consisted of three faculty members who had terminal degrees and several years of experience in teaching online, designing online environments, developing instruments, and publishing research, and one instructional designer with more than 10 years of experience designing/developing hybrid and online courses. Panel experts were contacted individually via e-mail and were provided with instructions, operational definitions, and a scale and rating form for review and comments/suggestions for improvement of the instrument. Additionally, the experts were provided with working definitions of the constructs (see Table 1) to rate the items in each construct concerning their relevance to the definition (DeVellis, 2003). Changes to the instruments were made based on recommendations from panel experts. The OCOI included 30 items and five subscales as follows: information relevance, information overload, course design, instructional activities and materials, and facilitation. The SMFS comprised eight items on a single subscale.

Stage 3: Data Collection and Analysis

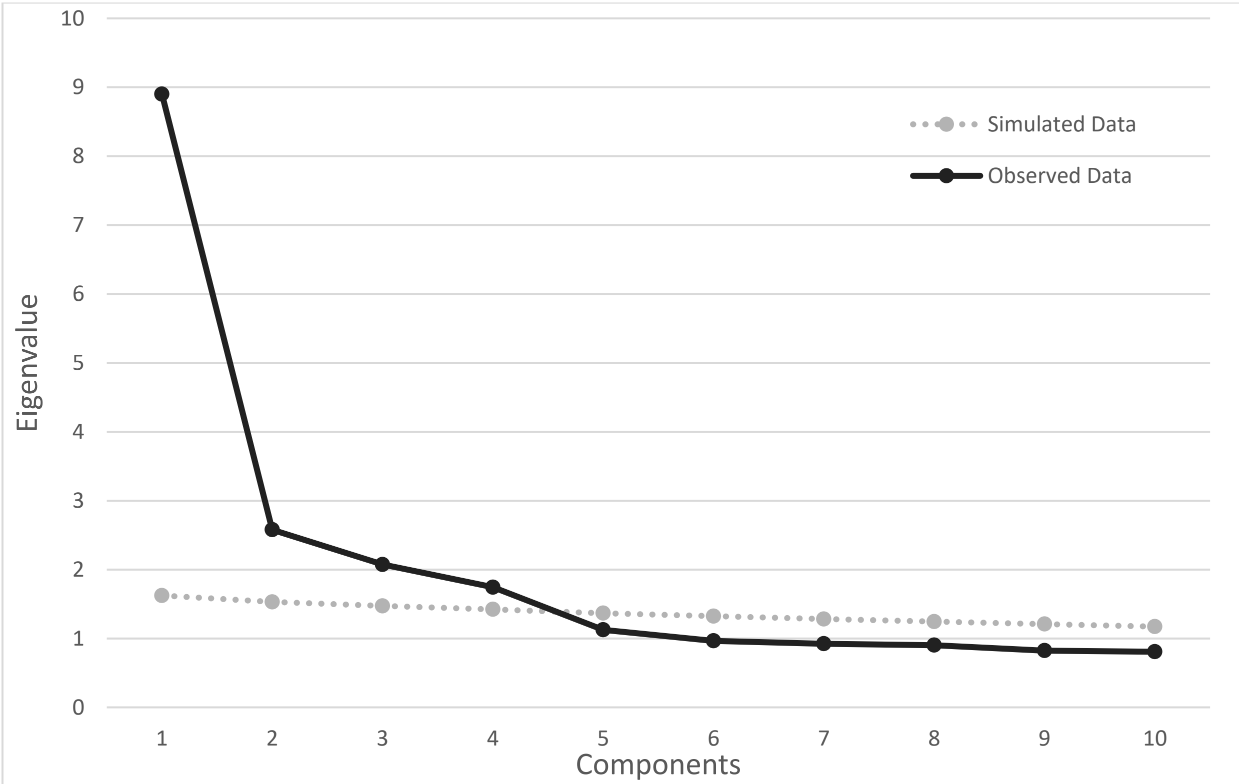
In stage 3, the items were administered, along with other scales, to the panel sample of 378 undergraduate students enrolled in online courses to validate the instruments. The main purpose of this stage was to establish the psychometric properties of the instrument. Preliminary analysis was conducted after the items were administered to the sample. The assumptions were checked for normality/linearity (Wilcox, 2013), and sample size adequacy was also checked (Bartlett, 1951). The principal component analysis was used as a data reduction technique to reduce observed variables into a smaller number of components (Worthington & Whittaker, 2006). The oblique (Promax) rotation was used because of the assumption that the factors underlying the items are correlated according to previous theoretical support (Field, 2009). The number of factors to be retained was determined using several methods. Factor extraction and rotation were conducted to get the loadings for each factor and to improve the interpretation of the factors (Mertler & Vannatta, 2016).

Results

OCOI: Exploratory Factor Analysis Results

Four criteria were used to determine the appropriate number of components to retain: eigenvalue, scree plot, total variance explained, minimum average partial (MAP) test, and parallel analysis. Upon examination of the eigenvalues, five factors were above the value of 1 and explained 54.73% of the total variance. Kaiser (1960) recommends retaining all factors with eigenvalues greater than 1. There is a consensus in the literature, however, that using eigenvalues is one of the least accurate measures to determine the number of factors to retain (Carpenter, 2018; Costello & Osborne, 2005). Previous research suggests that parallel analysis (PA) is more accurate than other methods to determine the number of factors to retain (Matsunaga, 2010). Velicer's MAP test is also a validated procedure that was used to decide on the number of factors to retain (O'connor, 2000). The Statistical Package for the Social Sciences (SPSS) with a subprogram was used to compute PA and MAP for the OCOI. The results from the PA indicated a four-factor structure. Similarly, a four-components solution was suggested by the original and revised MAP test. The scree plot was slightly ambiguous but also supported the retention of four factors. Therefore, four factors were retained based on the results of the PA, MAP test, and scree plot (see Figure 1).

Figure 1
Parallel Analysis Scree Plot Results



The four-factor structure yielded a total explained variance of 50.99%. Each retained item loaded distinctively on one of the four factors. Cross-loadings and multiple factor loadings have been identified as evidence of complex items reflecting the influence of more than one factor (Worthington & Whittaker, 2006). Examination of the pattern matrix revealed items from one scale with cross-loading or multiple factor loadings. Therefore, the items from the instructional activities and materials subscale were eliminated due to low factor loadings and/or loading to multiple subscales. In Table 2, the retained items are ordered and grouped by the size of their loadings.

Table 2

Summary of Exploratory Factor Analysis Results for the OCOI (n = 378)

Subscale and items	Component			
	1	2	3	4
Information relevance				
Information will be useful for my current or future job	.794			
Information will prepare me with practical knowledge and skills	.767			
Information is related to real-life situations	.766			
Information contributes to my success in this course	.757			

Subscale and items	Component			
	1	2	3	4
Information is related to my interest(s) outside of the online course	.663			
Information presented is what I need to know to be successful in the course	.601			
Facilitation				
The instructor is actively involved in the online environment		.869		
The instructor communicates clearly in writing throughout the course		.848		
The feedback provided by the instructor is constructive		.828		
The instructor is responsive to my questions		.784		
The instructor provides timely feedback		.776		
The instructor encourages learner participation in course activities/tasks		.732		
Course design				
The course tasks/assignments are easy to locate			.769	
The course is easy to navigate			.759	
The design (e.g., organization, presentation, i.e., look and feel) is consistent throughout the course			.756	
The course materials are easy to find			.756	
The design elements (e.g., colors, fonts, buttons, use of space) are visually pleasing			.701	
The course was logically organized			.660	
Information overload				
The number of readings is overwhelming				.763
There is an excessive amount of information to process in the course				.728
The course content is complex				.695
There are too many resources in the course				.674
The videos are too long				.621
The number of threads/replies posted in the online discussions is overwhelming				.585
Initial eigenvalue (all items)	8.90	2.58	2.07	1.74
Initial % of variance explained (all items)	29.67	8.59	6.91	5.81

Note. Factor loadings under .50 were removed for the retained constructs.

The SMFS: Exploratory Factor Analysis Results

The SMFS was examined with principal components analysis. Typically, factor analysis requires two steps: (a) factor extraction and (b) factor rotation. However, after factor extraction, an examination of the scale revealed a single underlying dimension. Thus, the component loadings of the individual items indicated a single construct. Therefore, no factor rotation was used. Eigenvalues and the scree plot were examined for factor retention. On inspection of the eigenvalues, only one factor was above the value of one and explained 62.21% of the total variance. The scree plot suggested retaining one factor and was in concurrence with the eigenvalues. Therefore, one factor was retained. Only items with a factor loading of at least .50 were interpreted, based on Comrey and Lee's (1992) factor loading guidelines. All item loadings were above .50, and there were no cross-loading items. In Table 3, the items are ordered and grouped by the size of their loadings.

Table 3

Summary of Exploratory Factor Analysis Results for the Student Mental Fatigue Survey (SMFS) (n = 378)

Item	Component
	1
Mental fatigue	
I feel stressed when doing coursework	.863
I feel overwhelmed when doing coursework	.856
I feel frustrated when doing coursework	.817
It is difficult to focus when doing coursework	.813
I feel anxiety when doing coursework	.788
I feel confused when doing coursework	.752
I feel tired when doing coursework	.748
It is difficult to relax immediately after doing coursework	.652
Initial eigenvalue	4.98
Initial % of variance explained	62.21

Note. All factor loadings were greater than .50 for the retained construct.

Reliability Analysis

Internal consistency and reliability analyses were conducted to determine the extent to which items correlated with each other and the degree to which items consistently measured the same construct as other items within that scale (Slavin, 2007). To determine the instrument's reliability, Cronbach's alpha coefficient was calculated. The final model for the OCOI retained 24 items and four subscales. The overall reliability of the OCOI was 0.89. Information relevance, facilitation, course design, and information overload subscales all had high to moderate reliabilities, with Cronbach's alpha ranging from 0.77 to 0.90. The final SMFS included eight items. The overall reliability was high (0.91). Further analysis indicated that this alpha would not increase with the deletion of any item(s). Table 4 includes the number of items, Cronbach's alpha coefficients, means, and standard deviations for the OCOI and SMFS.

Table 4

Online Course Overload Indicator (OCOI) and Student Mental Fatigue Survey (SMFS) Reliability Summary Statistics

Subscale	No. of items	Cronbach's α	*M*[a]	*SD*
OCOI				
Information relevance	6	0.81	3.97	0.63
Course design	6	0.83	3.87	0.62
Facilitation	6	0.90	3.76	0.79
Information overload[b]	6	0.77	2.88	0.78
SMFS				
Mental fatigue[b]	8	0.91	2.79	0.92

Notes. [a] Mean scores were calculated by adding up the scores of all items loaded to the scale and dividing the total by the number of items on the scale. [b] Negatively phrased items were reverse coded before running the calculations.

Discussion

The evidence from previous studies suggests that understanding the impacts of course design elements on students' level of mental fatigue is important because it may potentially impact learning and performance (Ackerman et al., 2010; Jensen et al., 2013), cognitive flexibility (Plukaard et al., 2015), and exploration of complex tasks (Sarkar & Parnin, 2017). However, there is a lack of information in the research on the effects of course design elements and mental fatigue in online environments. This may be due to mental fatigue being a difficult construct to measure and because up to the date of writing, no instruments have been identified that measure student mental fatigue in online environments. Therefore, the OCOI and the SMFS were developed to be used to fill this gap in the literature from an online learning perspective.

The feedback from students regarding course design and implementation elements is an important aspect in helping instructors provide quality instruction to learners. Therefore, a valid and reliable evaluation tool (such as the OCOI) would help instructors identify specific areas for improvement within the online course (e.g., content, design, and environment). In addition, the SMFS could help instructors understand the mental constraints of their learners in terms of whether they feel overwhelmed, confused, anxious, or frustrated when doing coursework. Additionally, online courses usually attract students from diverse backgrounds (e.g., working professionals needing flexible schedules, nontraditional students, etc.). Considering these learners' mental and physical workloads, improvements in the learning experience could make a difference in their learning outcomes (e.g., content retention and course performance). The four constructs identified on the OCOI gather the student perspective regarding overload indicators in the online environment, and they have been frequently mentioned by online students as sources of their frustrations (Alleyne Bayne, 2016; Barnard & Paton, 2007; Lambert et al., 2009).

Future Research and Limitations

This study has explored the design of two new instruments regarding online course overload indicators and their effects on students' mental fatigue. Considering the novelty of the subject studied, several areas can be further explored. Future studies using alternative statistical procedures (e.g., confirmatory factor analysis) could validate the developed instrument. A follow-up with confirmatory factor analysis on a new sample could be useful, as researchers recommend repeating instrument validation with a new data set for optimizing the scale length (Field, 2009; Worthington & Whittaker, 2006). These instruments can also be used to investigate whether course design elements predict mental fatigue in online courses. Additionally, studies can examine the relationship between academic performance and perceived student mental fatigue in an online environment, as well as whether improvements in course design decrease perceived student mental fatigue.

In this study, one limitation was that the researchers were not directly involved in the online course design, which would have given the study a point of reference for the quality of the online course environments. In future studies, researchers may consider directly reviewing and evaluating various online course design elements. The research should be expanded into the actual online course environment with instructor input and expert assessment of the course components along with the student-level data to correlate the constructs and their impact on learning outcomes. Additionally, future studies could involve multiple data collection points to explore the effects of online course design elements on students' mental fatigue in an online learning environment. Such longitudinal studies would allow researchers to monitor changes in student mental fatigue over time.

Conclusion

Several existing instruments are used for fatigue research in medicine. However, these instruments are not targeted toward the online environment—specifically, the design of online courses. Therefore, an important outcome of this study was identifying tools that educators can use to assess whether design elements in online instruction contribute to mental fatigue. Two instruments were created that can assist instructors teaching courses online to assess student perceptions of cognitive overload and mental fatigue when doing coursework. Specifically, the Online Course Overload Indicator (OCOI) was designed to measure students' perceptions of cognitive overload in online courses. The Student Mental Fatigue Survey (SMFS) was designed to measure students' perceptions of mental fatigue while taking online courses. The findings from this research study may be helpful for instructors seeking to optimize their online course design to promote better learning experiences for online learners. For those instructors who are new to online teaching and thus unprepared to teach in this environment, and/or for seasoned instructors who have never taught online, the OCOI could be used to better gauge where in the online course/environment students are being overloaded, and adjustments to the course can be provided as needed. Hence, the knowledge gained from this research study could enable practitioners in education to use these tools to facilitate online learning, thereby improving online course content in meaningful and relevant ways to promote student learning and satisfaction.

References

Ackerman, P. L. (2011). *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications*. American Psychological Association. https://doi.org/10.1037/12343-000

Ackerman, P. L., Kanfer, R., Shapiro, S. W., Newton, S., & Beier, M. E. (2010). Cognitive fatigue during testing: An examination of trait, time-on-task, and strategy influences. *Human Performance*, *23*(5), 381–402. https://doi.org/10.1080/08959285.2010.517720

Al Ma'mari, Q., Sharour, L. A., Al Omari, O. (2020). Fatigue, burnout, work environment, workload and perceived patient safety culture among critical care nurses. *British Journal of Nursing*, *29*(1), 28–34. https://doi.org/10.12968/BJON.2020.29.1.28

Alleyne Bayne, G. (2016, March 25). *An exploratory study of university students' mental fatigue in online courses* [Poster presentation]. Texas Tech Univeristy 15th Annual Graduate Student Research Poster Competition, Lubbock TX.

Ayres, P. (2006). Using subjective measures to detect variations of intrinsic cognitive load within problems. *Learning and Instruction*, *16*(5), 389–400. https://doi.org/10.1016/j.learninstruc.2006.09.001

Baker, C. (2010). The impact of instructor immediacy and presence for online student affective learning, cognition, and motivation. *Journal of Educators Online*, *7*(1), 1–30. https://doi.org/doi:10.9743/JEO.2010.1.2

Bakker, R. J., van de Putte, E. M., Kuis, W., & Sinnema, G. (2009). Risk factors for persistent fatigue with significant school absence in children and adolescents. *Pediatrics*, *124*(1), e89–e95. https://doi.org/10.1542/peds.2008-1260

Balkin, T. J., & Wesensten, N. J. (2011). Differentiation of sleepiness and mental fatigue effects. In P. L. Ackerman (Ed.), *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications* (pp. 47–66). American Psychological Association. https://doi.org/10.1037/12343-002

Barnard, L., & Paton, V. O. (2007, November). *Distance learning survey of Texas Tech University's fall 2006 distance and off-campus students*. https://www.depts.ttu.edu/opa/docs/Barnard_Paton_2007_Distance_Learning_Survey_TTU_F2006.pdf

Bartlett, M. S. (1951). The effect of standardization on a χ2 approximation in factor analysis. *Biometrika*, *38*(3/4), 337–344. https://doi.org/10.2307/2332580

Beiske, A. G., & Svensson, E. (2010). Fatigue in Parkinson's disease: A short update. *Acta Neurologica Scandinavica*, *122*(s190), 78–81. https://doi.org/10.1111/j.1600-0404.2010.01381.x

Boksem, M. A. S., Meijman, T. F., & Lorist, M. M. (2005). Effects of mental fatigue on attention: An ERP study. *Cognitive Brain Research*, *25*(1), 107–116. https://doi.org/10.1016/j.cogbrainres.2005.04.011

Boksem, M. A. S., & Tops, M. (2008). Mental fatigue: Costs and benefits. *Brain Research Reviews*, *59*(1), 125–139. https://doi.org/10.1016/j.brainresrev.2008.07.001

Bolliger, D. U., & Inan, F. A. (2012). Development and validation of the Online Student Connectedness Survey (OSCI). *The International Review of Research in Open and Distributed Learning*, *13*(3), 41-65. https://doi.org/10.19173/irrodl.v13i3.1171

Carpenter, S. (2018). Ten steps in scale development and reporting: A guide for researchers. *Communication Methods and Measures*, *12*(1), 25–44. https://doi.org/10.1080/19312458.2017.1396583

Chalder, T., Berelowitz, G., Pawlikowska, T., Watts, L., Wessely, S., Wright, D., & Wallace, E. P. (1993). Development of a fatigue scale. *Journal of Psychosomatic Research*, *37*(2), 147–153. https://doi.org/10.1016/0022-3999(93)90081-P

Chen, C. Y., Pedersen, S., & Murphy, K. L. (2011). Learners' perceived information overload in online learning via computer-mediated communication. *Research in Learning Technology*, *19*(2), 101–116. https://doi.org/10.1080/21567069.2011.586678

Clark, R., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning* (4th ed.). John Wiley & Sons. https://doi.org/10.1002/9781119239086

Clark, R., Nguyen, F., & Sweller, J. (2006). *Efficiency in learning: Evidence-based guidelines to manage cognitive load*. John Wiley & Sons.

Comrey, A. L., & Lee, H. (1992). *A first course in factor analysis* (2nd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9781315827506

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment Research & Evaluation*, *10*(7), 1–9. https://doi.org/10.7275/jyj1-4868

Csathó, Á., van der Linden, D., Hernádi, I., Buzás, P., & Kalmár, G. (2012). Effects of mental fatigue on the capacity limits of visual attention. *Journal of Cognitive Psychology*, *24*(5), 511–524. https://doi.org/10.1080/20445911.2012.658039

DeLuca, J. (Ed.). (2005). *Fatigue as a window to the brain*. MIT press. https://doi.org/10.7551/mitpress/2967.001.0001

DeVellis, R. F. (2003). *Scale development: Theory and applications* (2nd ed.). Sage Publications.

Edwards, J. R., & Cooper, C. L. (2013). The person-environment fit approach to stress: Recurring problems and some suggested solutions. In C. L. Cooper (Ed.), *From stress to wellbeing: Vol. 1. Theory and research on occupational stress and wellbeing* (pp. 91–108). Palgrave Macmillan. https://doi.org/10.1057/9781137310651_5

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). Sage Publications. https://uk.sagepub.com/en-gb/eur/discovering-statistics-using-ibm-spss-statistics/book257672

Garrison, D. R., Anderson, T., & Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, *2*(2–3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Guo, P. J., Kim, J., & Rubin, R. (2014, March). How video production affects student engagement: An empirical study of MOOC videos. *L@S '14: Proceedings of the First ACM Conference on Learning @ Scale Conference* (pp. 41–50). Association for Computing Machinery. https://doi.org/10.1145/2556325.2566239

Guramatunhu, P. (2015). The gender shift in enrollment patterns in higher education: A case study of a school administration program. *Advancing Women in Leadership*, *35*, 120–133. https://doi.org/10.21423/awlj-v35.a137

Hafezi, S., Zare, H., Najafi Mehri, S., & Mahmoodi, H. (2010). The Multidimensional Fatigue Inventory validation and fatigue assessment in Iranian distance education students. *Proceedings of the 4th International Conference on Distance Learning and Education (ICDLE)* (pp. 195–198) Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICDLE.2010.5606006

Harris, S. M., Larrier, Y. I., & Castano-Bishop, M. (2011). Development of the Student Expectations of Online Learning Survey (SEOLS): A pilot study. *Online Journal of Distance Learning Administration*, *14*(4). https://eric.ed.gov/?id=EJ960578

Herlambang, M. B., Taatgen, N. A., & Cnossen, F. (2019). The role of motivation as a factor in mental fatigue. *Human Factors*, *61*(7), 1171–1185. https://doi.org/10.1177/0018720819828569

Hinkin, T. R., Tracey, J. B., & Enz, C. A. (1997). Scale construction: Developing reliable and valid measurement instruments. *Journal of Hospitality and Tourism Research*, *21*(1), 100–120. https://doi.org/10.1177/109634809702100108

Hockey, R. (2013). *The psychology of fatigue: Work, effort and control*. Cambridge University Press. https://doi.org/10.1017/CBO9781139015394

Holmes, C. M., & Reid, C. (2017). A comparison study of on-campus and online learning outcomes for a research methods course. *The Journal of Counselor Preparation and Supervision*, *9*(2), 1–24. https://doi.org/10.7729/92.1182

Jensen, J. L., Berry, D. A., & Kummer, T. A. (2013). Investigating the effects of exam length on performance and cognitive fatigue. *PLoS One*, *8*(8), e70270. https://doi.org/10.1371/journal.pone.0070270

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*(1), 141–151. https://doi.org/10.1177/001316446002000116

Keller, J. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional design theories and models: An overview of their current status* (pp. 383–434). Lawrence Erlbaum. https://doi.org/10.4324/9780203824283

Lambert, M., Sattler, S., & Paton, V. O. (2009, June). *Distance learning survey of Texas Tech University's fall 2008 distance and off-campus students*. https://www.depts.ttu.edu/opa/docs/Lambert_Sattler_Paton_2009_Distance_Learning_Survey_TTU_F2008.pdf

Lee, A., Son, S. M., & Kim, K. K. (2016). Information and communication technology overload and social networking service fatigue: A stress perspective. *Computers in Human Behavior*, *55*, 51–61. https://doi.org/10.1016/j.chb.2015.08.011

Matsunaga, M. (2010). How to factor-analyze your data right: Do's, don'ts, and how-to's. *International Journal of Psychological Research*, *3*(1), 97–110. https://doi.org/10.21500/20112084.854

Mayadas, F., Miller, G. E., & Sener, J. (2015, July). *Updated e-learning definitions*. Online Learning Consortium. http://onlinelearningconsortium.org/updated-e-learning-definitions/

Mertler, C. A., & Vannatta, R. A. (2016). *Advanced and multivariate statistical methods: Practical application and interpretation* (6th ed.). Routledge. https://doi.org/10.4324/9781315266978

Miller, G. (1994). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *101*(2), 343–352. https://doi.org/10.1037/0033-295x.101.2.343

Mizuno, K., Tanaka, M., Fukuda, S., Yamano, E., Shigihara, Y., Imai-Matsumura, K., & Watanabe, Y. (2011). Low visual information-processing speed and attention are predictors of fatigue in elementary and junior high school students. *Behavioral and Brain Functions*, *7*(1), 1–7. https://doi.org/10.1186/1744-9081-7-20

Mota, D. D. C. F., & Pimenta, C. A. M. (2006). Self-report instruments for fatigue assessment: A systematic review. *Research and Theory for Nursing Practice: An International Journal*, *20*(1), 49–78. https://doi.org/10.1891/rtnp.20.1.49

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill.

O'connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers*, *32*(3), 396–402. https://doi.org/10.3758/BF03200807

O'Sullivan, P. B., Hunt, S. K., & Lippert, L. R. (2004). Mediated immediacy: A language of affiliation in a technological age. *Journal of Language and Social Psychology*, *23*(4), 464–490. https://doi.org/10.1177/0261927X04269588

Palmer, L. K. (2013). The relationship between stress, fatigue, and cognitive functioning. *College Student Journal*, *47*(2), 312–325. https://www.ingentaconnect.com/content/prin/csj/2013/00000047/00000002/art00007

Plass, J. L., Moreno, R., & Brunken, R. (Eds.). (2010). *Cognitive load theory*. Cambridge University Press. https://doi.org/10.1017/CBO9780511844744

Plukaard, S., Huizinga, M., Krabbendam, L., & Jolles, J. (2015). Cognitive flexibility in healthy students is affected by fatigue: An experimental study. *Learning and Individual Differences*, *38*, 18–25. https://doi.org/10.1016/j.lindif.2015.01.003

Roach, V., & Lemasters, L. (2006). Satisfaction with online learning: A comparative descriptive study. *Journal of Interactive Online Learning*, *5*(3), 317–332. https://files.eric.ed.gov/fulltext/ED447310.pdf

Roberson, R. (2013, September). Helping students find relevance. *Psychology Teacher Network*, *23*(2), 18–20.

Roelle, J., Lehmkuhl, N., Beyer, M., & Berthold, K. (2015). The role of specificity, targeted learning activities, and prior knowledge for the effects of relevance instructions. *Journal of Educational Psychology*, *107*(3), 705–723. https://doi.org/10.1037/edu0000010

Sarkar, S., & Parnin, C. (2017). Characterizing and predicting mental fatigue during programming tasks. *Proceedings: 2017 IEEE/ACM 2nd International Workshop on Emotion Awareness in Software Engineering* (pp. 32–37). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/SEmotion.2017.2

Slavin, R. E. (2007). *Educational research in an age of accountability*. Allyn & Bacon.

Sweller, J. (2008). Human cognitive architecture. In J. M. Spector, M. D. Merrill, J. Van Merrienboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed., pp. 369–381). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203880869

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*(3), 251–296. https://doi.org/10.1023/A:1022193728205

Tugtekin, U. (2022). Development and validation of an instrument for online learning fatigue in higher education. In G. Durak & S. Çankaya (Eds.), *Handbook of research on managing and designing online courses in synchronous and asychronous environments* (pp. 566–586). IGI Global.

https://doi.org/10.4018/978-1-7998-8701-0.ch028

van der Linden, D. (2011). The urge to stop: The cognitive and biological nature of acute mental fatigue. In P. L. Ackerman (Ed.), *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications.* (pp. 149–164). American Psychological Association. https://doi.org/10.1037/12343-007

Vercoulen, J. H. M. M., Swanink, C. M., Fennis, J. F., Galama, J. M., van der Meer, J. W., & Bleijenberg, G. (1994). Dimensional assessment of chronic fatigue syndrome. *Journal of Psychosomatic Research*, *38*(5), 383–392. https://doi.org/10.1016/0022-3999(94)90099-x

Wanstreet, C. E. (2006). Interaction in online learning environments: A review of the literature. *Quarterly Review of Distance Education*, *7*(4), 399–411. https://www.learntechlib.org/p/106711/

Wilcox, R. R. (2013). *Introduction to robust estimation and hypothesis testing* (3rd ed.). Elsevier. https://doi.org/10.1016/C2010-0-67044-1

Worthington, R., & Whittaker, T. (2006). Scale development research: A content analysis and recommendations for best practices. *The Counseling Psychologist*, *34*(6), 806–838. https://doi.org/10.1177/0011000006288127

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SLOAN: Social Learning Optimization Analysis of Networks

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Abstract

Online discussion research has mainly been conducted using case methods. This article proposes a method for comparative analysis based on network metrics such as information entropy and global network efficiency as more holistic measures characterizing social learning group dynamics. We applied social learning optimization analysis of networks (SLOAN) to a data set consisting of Coursera courses from a range of disciplines. We examined the relationship of discussion forum uses and measures of network efficiency, characterized by the information flow through the network. Discussion forums vary greatly in size and in use. Courses with a greater prevalence of subject-related versus procedural talk differed significantly in seeking but not disseminating behaviors in massive open online course discussion forums. Subject-related talk was related to higher network efficiency and had higher seeking and disseminating scores overall. We discuss the value of SLOAN for social learning and argue for the experimental study of online discussion optimization using a discussion post recommendation system for maximizing social learning.

Keywords: social learning optimization analysis of networks, SLOAN, social cognitive theory, social learning, information theory, network analysis

SLOAN: Social Learning Optimization Analysis of Networks

The advent of the Internet and information technology is radically reshaping social relations. No field has been unaffected, especially educational technology. New data analysis technologies and new possibilities unlocked by increasing computing power are reshaping research by introducing advanced statistical modeling techniques. Researchers can use powerful open-source information tools to create new fields and new tools of investigation. This same process repeating itself across all fields of human activity, dubbed *technological disruption* by some, shows how information technology can remake human activity. From a social-cultural perspective, information technology as a psychological tool serves knowledge transmission and production. Psychological tools have the characteristic of being endlessly combinatorial and expressive (Vygotsky, 1986; Wertsch, 1985). At the same time, information technology has a material dimension as well: the interconnectedness of information technology, and computational tools and data, can be put to work to serve particular ends that create the conditions for new activities to arise. For Marx (1839–1841/1973), automation leads to the accumulation of productive capital. Somewhat presciently, he divined that these forms of infinite labor surplus of information machines would remake social relations. Thus, information technology in both its material and psychological dimension is sui generis, a tool of infinite productive capacity that, in dialectical fashion, expands the sphere of human activity while automating away human labor.

Educational technologists have eagerly incorporated new technological and methodological developments from data science into their research (Wise & Cui, 2018). This is evidenced by the growth in data-focused fields of educational data mining and learning analytics but also in the growth of mobile and multimodal technologies using user data to curate learning experiences. Whereas much educational technology research has focused on developing learning tools and measuring impact, comparatively little research has explored the development of learning interfaces, or

> the windows on the world through which a person views information and which cause a certain quality of learning to occur. Interfaces to learning are the cognitive artifacts, the resources for learning, that populate the learning environment and occasion learning (Duchastel, 1996, p. 207).

Although the idea of learning interfaces can be traced back to Duchastel's work with a special committee of the North American Treaty Alliance (NATO) investigating the possibility of advanced educational technology (Liao, 1996), few researchers in the intervening years have focused on educational interface design (Kloos et al., 2020), and learning interfaces have not evolved considerably in the intervening years. We may have more data, but educational technologists are still searching for ways to incorporate learning analytics into learning technologies (Wise et al., 2015). One issue is that learning technologies are still primarily focused on formal learning activities, and content and learning interfaces have thus remained primarily static, orchestrated affairs. Much educational technology is focused on tools that are helpful for teaching and learning knowledge and skills: for instance, an important aspect of the field of self-regulated learning is focused on leveraging multimodal learner data to support the development of meta-cognitive skills (Winne, 2017). However, few have explored how information technology creates new opportunities for knowledge production as well as reproduction or how information technology creates new contexts for learning. One exception has been discussion forums. The seminal work around the Knowledge Forum and computer-supported collaborative learning (Scardamalia & Bereiter, 2014) provides a glimpse of the potential of information technology for expanding learning possibilities by harnessing network effects of groups of learners. Although much recent research has applied new analytical techniques to the study of online discourse (Rosé, 2017), technology-supported learning environments have not kept pace with new innovations in Internet technologies that exploit advanced statistical techniques and the abundance of data and computing power to create more dynamic and adaptive learning interfaces (Wise et al., 2015), for instance, interfaces that can moderate and curate user discussion threads based on their interactions. Studies of online discourse show that differential patterns of interaction lead to qualitatively different learning outcomes (Fu et al., 2016). For instance, Wise et al., (2014) have demonstrated that *speaking*, or posting, is predicted by *listening*, or attending to others' posts. Yet few studies to date have explored algorithmic methods for fostering those interaction patterns associated with better learning outcomes (Rosé et al., 2008).

Online discussion forums are a ubiquitous part of contemporary connected living. We use them to communicate, share, express, and interact. At the most fundamental level, they are about information sharing. From them, we can get crowdfunded advice, and we can learn from the wisdom of the crowd. Indeed, most turn to the Internet for answers to their questions because they know that their question has already been asked and answered many times before. Thus, we are interested in optimizing discussion forums for social learning. In network analysis terms, we argue that improving the flow of information, or the efficiency of the network, can help create better online learning communities and foster better discourse overall. *Optimization* (Boyd & Vandenberghe, 2004), in mathematical parlance, refers to solutions that minimize error given a specific value function. *Network optimization* refers to finding all the connections that maximize benefit (or, equivalently, minimize error). In the context of social learning networks, the benefit equates to maximizing learning opportunities that can be gained from online connections. In recent years, online discussion forum research has seen an explosion, and analytical methods have been a large focus of this research (Ruipérez-Valiente et al., 2020; Zhu et al., 2020). However, this research has largely been approached in a case-based fashion, with a concomitant variety of approaches. The profusion of analytical methods (Almatrafi & Johri, 2019; O'Riordan et al., 2020) and the lack of controlled experiments make it hard to draw strong conclusions based on the extant literature. The lack of a unifying theoretical framework and method are partly responsible. Information network theory can arguably bridge perspectives and help identify features of discussion forums for comparative analysis and experimental study. Whereas many researchers have applied social network analysis to the study of online discussion forums (Jan et al., 2019; Kim & Ketenci, 2019), most have focused on connections and have not considered the quality of those connections in terms of content and message (Wise et al., 2017)—in other words, the flow of information through the network. In their systematic review of social network analysis in online learning, Jan et al. (2019) found a general lack of consideration to attributional and performance variables in the extant literature. The field of network theory provides tools to analyze the flow of information through networks. Information flow is a fundamental aspect of social learning in online discussion forums. This is central to understanding how discussion features are related to better learning outcomes. We borrow the related notions of information entropy and network efficiency (Brinton et al., 2016; Latora & Marchiori, 2001) to understand the diffusion of information within a group. *Information entropy* refers to the overall structure of the information graph (Dehmer & Mowshowitz, 2011) and *network efficiency* to the degree to which information flows through the graph (Latora & Marchiori, 2001). In the present study, we examine network efficiency across 60 Coursera courses collected over a one-year period by Rossi and Gnawali (2014). We compare courses to understand how course features might influence discussion forum efficiency. More efficient online discussion forums can promote better social learning and better social outcomes.

Literature Review

In the following sections, we review social learning research in the context of discussion forums, and we examine the relationship between massive open online course (MOOC) discussions and learning outcomes.

Social Learning

According to Crittenden (2005), social learning theory "explains human behavior in terms of continuous reciprocal interaction between cognitive, behavioral, and environmental influences" (p. 960). Social learning theories (Deaton, 2015) allow us to examine and understand the social factors that contextualize and influence teaching and learning. According to social learning theories (Hill et al., 2009), collective behavior is considered key in shaping learning in a social context. Indeed, among the dimensions that shape social learning is shared construction of knowledge. In fact, Reed et al. (2010) note that a critical distinguishing characteristic of social learning is that a process—to be considered social learning—ought to occur through social interactions between actors in a network. As such, the collaborative purpose is important to the purpose of the network.

Theories of social learning emphasize the importance of discourse to the performance of groups. In fact, discourse is widely recognized as a ubiquitous and important feature of teaching and learning in and out of classrooms (Gilbert & Dabbagh, 2004). The notion of the importance of discussions has had a strong impact in educational research (Wu & Hiltz, 2004). Discussion is considered an important driver for social learning development (Soter et al., 2008). As such, to successfully coordinate learning, a key objective is to foster and facilitate effective discussions among participants in a group learning setting (Hill et al., 2009; Lee & Recker, 2021), especially in online environments (Raković et al., 2020).

Since the advent of mobile computing, the rapid diffusion of educational technology has offered new opportunities for teaching, learning, and research (Castañeda & Williamson, 2021; Lemay, Doleck, & Bazelais, 2021). The need to better understand social learning is made more acute as more learning and teaching starts to take place in online learning environments (Castro & Tumibay, 2019). Researchers have emphasized ever more the need to examine educational technology's features and mechanisms that promote effective teaching and learning (Kimmons et al., 2021).

A common theme underlying the literature on online learning environments is that discussion forums are a crucial feature of online learning environments (Lee & Recker, 2021; Tirado et al., 2012), not only because they enable and support interactions and communication (Almatrafi & Johri, 2019) but because they facilitate the sharing of ideas and knowledge (Andresen, 2009; Rovai, 2007). The literature on online learning environments informs us that the utility of online learning environments such as MOOCs is often tied to their ability to provide conditions that enable effective discourse (Goshtasbpour et al.; Hill et al., 2009).

MOOCs and Discussion Forums

Discussion forums—widely seen as important in fostering and facilitating communication and interaction among participants in learning communities (Hammond, 2005; Rovai, 2007)—are considered crucial for social learning (Almatrafi & Johri, 2019; Goshtasbpour et al., 2021; Thomas, 2002). The topic of computer-mediated discussion forums has drawn significant attention from educational technology researchers (Gay & Betts, 2020). Prior research has extensively studied discussion forums for teaching and learning (Chiu & Hew, 2018), particularly as key learning spaces in online courses and learning management systems (Marra, 2006). For the current study, we focus on a specific context of MOOCs. The argument for prioritizing MOOCs in the current study starts with an observation that “the MOOC environment has great potential for leveraging social learning on a global scale” (Loizzo & Ertmer, 2016, p. 1028). Indeed, MOOCs have attracted scholarly attention that continues to grow (Ruipérez-Valiente et al., 2020). In fact, a recent review notes that social learning is a key topic of research on MOOCs (Zhu et al., 2020). Common to most studies on MOOC discussion forums is an acknowledgment that MOOCS often do not offer individual instructor support to students (Moore et al., 2020)—that in most instances of MOOC discussion forums, they “are the only channel for support and for information exchange between peers” (Boroujeni et al., 2017, p. 128).

Early work on MOOC discussion forums relied heavily on frequency counts and other quantitative measures (Marra, 2006; O’Riordan et al., 2020). In fact, O’Riordan et al. (2020) note that research on MOOC discussion forums has been “dominated by assessments of the quantity rather than the quality of interaction” (p. 691). Yet Moore et al. (2020) note that the volume of text in MOOC discussion forums is both an opportunity and challenge for researchers.

With the availability of fine-grained data, the analyses of discussion forums have expanded due to the creative use of data and advanced analytical methods. Researchers have used different methods for understanding various aspects of discussion forums and for extracting actionable insights from forum data across a wide variety of MOOCs (Ruipérez-Valiente et al., 2020). Almatrafi and Johri (2019) conducted a review of MOOC discussion forums and extracted the following common methods for analyzing them: observation, qualitative data, statistics, data mining, visualization, and social network analysis. Furthermore, several researchers underscore the need to examine the links between discussion forums and learning outcomes (Almatrafi & Johri, 2019; Galikyan et al., 2021; Joksimović et al., 2017). Such efforts are also salient for understanding if participating (or not participating) in MOOC discussion forums helps or hinders learning and learning outcomes.

MOOC Discussion Forums and Learning Outcomes

Discussion forums serve as an important means by which participants overcome communication constraints. As noted at the outset, discussions can impact teaching and learning and, in turn, learning outcomes. Importantly, discussion forums are fertile grounds for research providing data sources for

> (a) measures of engagement, by tracking users' forum viewing patterns; (b) measures of mastery, understanding, or affect, generated by applying natural language processing to the raw text of forum posts; and (c) social network data by assembling graphs where various connections in the fora constitute edges. (Gardner & Brooks, 2018, p. 138)

Given the rich data available from discussion forums, a recent and growing body of work has specifically focused on the association between MOOC discussion forums and learning outcomes.

The role of discourse behavior and forum activities has been explored in a number of studies (e.g., O'Riordan et al., 2020), with some documenting an association between discourse behavior and learning (e.g., Wang et al., 2015) and others finding correlations between forum activity and course success (e.g., Santos et al., 2014). To contextualize the link between discourse on MOOCs and performance, Dowell et al. (2015) note that discourse features accounted for 5% of the variance in the performance in their analysis. Yet other research finds active participants contributing posts unrelated to the course at a higher rate (Feng et al., 2015). Almatrafi and Johri (2019), in reviewing the literature on discussion forums in MOOCs, summarize the findings apropos participation and performance by noting that "there is a correlation between participation in the forums and completion and performance" (p. 420).

Studies in this area have also focused on the cognitive dimension of learning. With a focus on the content generated by learners in a MOOC discussion forum, Galikyan et al. (2021) examined the link between learner cognitive engagement and performance, finding a negative relationship. Regarding social interactions in MOOCs, one strand of research focuses on social presence. For instance, Zou et al. (2021) find that certain social presence is linked with higher network prestige in MOOC discussion forums.

Comparative analysis has also been an active area of analysis in MOOC forum research. For example, some studies adopting a comparative perspective have documented differences across MOOCs (e.g., Jiang et al., 2014; Joksimović et al., 2016). Other research has examined differences between contributors and non-contributors to discussion forums (Wise & Cui, 2018). The authors document a higher rate of passing the course for contributors. Similarly, other studies have documented better scores for learners participating in MOOC discussions (Tseng et al., 2016). Research has also suggested that MOOC discussion forum activities can influence learning and achievement differently (e.g., Chiu & Hew, 2018). These differences highlight the importance of comparing not only between MOOCs but also between different types of learners.

Focusing on the methodological issues and challenges, prior research has raised concerns regarding operationalizing discussion forum use (Bergner et al., 2015; Tang et al., 2018; Zhu et al., 2016). In addition to the operational issues of discussion forum use, concerns have also been raised about the variability in the definition and operationalization of performance. All this speaks to the need for precise estimations of both forum use and success so that we can better understand the conditions that are necessary or adequate for optimizing the use of discussion forums for improved learning experiences and outcomes.

However, viewed more generally, the empirical research is equivocal about the association between discussion forum participation and learners' outcomes, especially with respect to which aspects of MOOC discussions are consistently effective. Rather than merely describing MOOC discussion forum use, we suggest that it is crucial to better understand how learners' participation in MOOC discussion forums is associated with learning outcomes as a way to elaborate a theory of social network learning. We build upon prior research in MOOC discussion forums, employing optimization theory to measure and compare the efficiencies of discussion forums. In network theory terms, *efficiency* refers to how well information flows through a network. Thus, we aim to compare network features of discussion and how they are related to MOOC learning outcomes.

Study Purpose

Our overarching purpose is to develop learning interfaces (Duchastel, 1996) that augment human ability as Engelbart (1962) and the early trailblazers of personal computing envisioned, wherein the distributed intelligence can empower learners and maximize learning outcomes through online interactions. As discussion forum activity is associated with learning, we seek to develop tools (e.g., algorithms) that empower learning in discussion forums. In the present study, we outline an approach to the study of social learning networks employing a convex optimization algorithm to calculate the learning benefit (network efficiency) of social learning in MOOC discussion forums, which we call social learning optimization analysis of networks (SLOAN). Using a comparative approach, we sought to answer the following question: How do MOOC discussion forums compare in terms of the efficiency of their social learning networks?

Methods

Theoretical Framework

Our research is informed by socio-constructivist and social cognitive theory. A fundamental aspect of learning resides in its social dimension—that is to say, learning is a social activity, and focusing strictly on the individual cognitive aspect ignores how learning functions in social groups. Specifically, we appeal to the dual processes of externalizing and internalizing learning (Vygotsky, 1986) that posit that internal intra-cognitive processes first arise as external inter-cognitive processes before being internalized by the individual. We also invoke the social learning behaviors of modeling—demonstrating a target skill or behavior—and vicarious learning—learning from the experiences of others (Bandura, 1986). A MOOC discussion forum helps users exchange information; however, it is also a social artifact that preserves the interactions and also supports modeling and vicarious learning from others' experiences.

Study Design

We employed SLOAN, developed by Brinton et al. (2016, 2018). In a previous study, we presented an implementation and performed a confirmatory analysis (Doleck et al., 2021); we now report on a replication study. As we used pre-existing data from older courses, we employed a retrospective comparative study design.

Data Source

We employed an open-source data set of 60 Coursera discussion forums collected and made available by Rossi and Gnawali (2014). The anonymized data consist of the complete data set of these courses, many having been taught many times to many sections. The sample sizes of courses (*N*) range from as little as 46 to as many as 5,172. The courses cover a wide range of topics, as can be discerned by their course titles (Table 1), but skew toward finance and science, in particular, computer science and programming.

Table 1

Coursera MOOC Data Set

Course	*N*	Total threads	Total posts
Numerical Analysis (French)	46	125	843
Asset Pricing	170	681	3,158
Automata	290	472	3,269
Big Data and Education	423	604	5,126
Bioinformatics	580	1,191	10,245
Blended Learning	1,913	4,734	27,762
Synapse, Neurons, and Brains	1,261	1,181	17,081
Climate Literacy	636	1,105	19,222
Compilers	221	457	2,668
Computational Methods for Data Analysis	127	193	1,135
Cryptography	310	433	4,170
Physical Sciences (Spanish)	105	121	1,464
Data Analysis	1,247	1,979	23,165
Data Science	3,928	4,802	52,927
Design	503	618	10,206
Designing Cities	788	523	10,033
Digital Media	1,732	2,562	23,245
Data Structures and Algorithms (Chinese)	148	284	1,227
Digital Signal Processing	261	668	3,529
E-learning and Digital Cultures	480	438	7,523
Understanding Einstein	981	1,587	19,590
Finance	873	941	12,407
Networks: Friends, Money, and Bytes	68	113	627
Game Theory	355	368	5,012
Gamification	2,431	1,766	47,570

Genomic Science	176	238	2,654
Global Warming	355	1,047	7,799
Human–Computer Interaction	557	1,041	9,416
History of Rock	524	392	9588
Humankind	2,936	3,353	69,313
Intro to Programming (French)	427	674	5,676
Intro to Java (French)	434	687	7,310
Intro to EU Law	831	808	11,510
Intro to Psychology	4,589	9,970	103,449
Intro to Statistics	1,512	1,197	17,012
Inspiring Leadership Through Emotional Intelligence	10447	8,482	65,852
Linear Programming	409	776	6,201
Mathematical Methods for Quantitative Finance	172	196	2,950
Mental Health	969	2,989	21,049
Machine Learning	4,262	5,653	64,362
Nanotechnology	504	860	9,394
Neural Networks	817	1,368	11,677
Natural Language Processing	759	1,261	12,888
Online Games	882	899	18,009
Organizational Analysis	2,623	2,579	64,831
Probabilistic Graphical Models	464	941	5,270
Bioinformatics: Introduction and Methods (Chinese)	238	342	3,651
Introduction to Computing (Chinese)	418	873	5,811
Precalculus (Spanish)	179	317	2,324
Functional Programming	1,042	1,622	12,255
Programming 1	3,042	3,590	46,666
Programming 2	842	1,196	8,690
Relationships	1,851	2,109	55,926
Scientific Writing	1,691	1,528	79,042
Social Network Analysis	545	938	9,202
Startups	5,172	6,730	76,890
Statistics 1	2,953	2,938	35,892
Useful Genetics	443	881	7,697
Video Games in Learning	1,531	9,261	35,804

Virology	769	967	11,123

Note. MOOC = Massive open online course; EU = European Union.

Instrument

SLOAN is a convex optimization algorithm (Brinton et al., 2016) that maximizes connections (equivalently formulated as minimizing the distance) between knowledge seekers and knowledge disseminators in online learning discussion forums subject to constraints. Convex optimization is a family of algorithms for solving multivariate problems that are linear in their constraints. Convex graph optimization problems refer to points that are linearly connected within a space and do not have analytic—that is, exact—solutions. Minimums and maximums are discovered using numerical methods including gradient descent. SLOAN uses a variant of gradient descent where the points are projected on a solution region (defined by the constraints). In Figure 1, we observe that users' (u) knowledge-seeking ($s_{u,k}$) and knowledge-disseminating ($d_{u,k}$) behaviors on a given topic (k) can be defined as functions of users' question-asking tendency ($q_{u,r,k}$). The log term represents the diminishing returns of multiple posts (p) on a given topic (k), effectively a penalty for multiple postings. An adjacency matrix representing user–user connections, that is, their posts and replies, across topics is optimized using a variation of the alternating method of multipliers employing projected gradient descent (Boyd & Vandenberghe, 2004; Brinton et al., 2016) to produce a network of optimal connections between knowledge seekers and knowledge disseminators on specific topics.

Figure 1

Knowledge-seeking and knowledge demonstration as functions of question-asking tendency

$$q_{u,r,k} = \frac{\sum_{p \in P_{r,u}} \theta_{p,k} \cdot Q(p)}{\sum_{p \in P_{r,u}} \theta_{p,k}}$$

$$d_{u,k} = \sum_{r} \left(1 - q_{u,r,k}\right) \cdot log\left(1 + \sum_{p \in P_{r,u}} \theta_{p,k} \cdot \left|x'_p\right|\right)$$

$$s_{u,k} = \sum_{r} q_{u,r,k} \cdot log\left(1 + \sum_{p \in P_{r,u}} \theta_{p,k} \cdot \left|x'_p\right|\right)$$

Note. Users' (u) knowledge-seeking ($s_{u,k}$) and knowledge-disseminating ($d_{u,k}$) behavior on a given topic (k) can be defined as functions of users' question-asking tendency ($q_{u,r,k}$).

Procedure

Each course's discussion forum was analyzed using SLOAN. Data were prepared by sanitizing inputs using the Beautiful Soup Python package to remove markup language and segmented and lemmatized using the Stanford Natural Language Toolkit (nltk) as standard practice in natural language processing to facilitate the application of algorithms that rely on frequentist distributions such as topic induction. Topics were inferred using Latent Dirichlet allocation (Blei, Ng, & Jordan, 2003). Seeking and disseminating behaviors were calculated based on weighted averages of posting frequencies by topic. We report on three measures of network efficiency for reliability and validity: the benefit calculated through SLOAN, the ratio of observed and optimized eigenvalues as a measure of overall network connectedness, and the global efficiency (Latora & Marchiori, 2001), which is a related measure of information flow through the network. Both SLOAN and global efficiency algorithms can be considered variants of shortest path algorithms, which are used extensively in network analysis (Dehmer & Mowshowitz, 2011).

Subsequently we compared MOOCs based on the dominating talk within the discussion forum, whether it was subject-related or procedural talk, using simple *t*-tests. Forums dominated by subject-related talk and those dominated by procedural talk were grouped based on the inferred topics. A course with a higher prevalence of keywords such as *assignment*, *quiz*, and *homework* was classified as dominated by procedural talk. A course with a higher prevalence of subject-related keywords such as "state, european, member, union" for a course on European Union Law was classified as dominated by subject-related talk.

Results

Seeking and disseminating scores and observed and optimized social learning network efficiency (Benefit) are presented for the following: courses with highest seeking tendency (Table 2), courses with highest disseminating tendency (Table 3), and courses with highest network efficiency (Table 4).

As can be observed in Figures 2–5, observed and optimized social learning network efficiency (Benefit) appears negatively related to seeking and disseminating tendency. Interestingly, we noticed an increased disseminating tendency in humanities-oriented courses and increased seeking in science-oriented courses. Notice how optimized benefits (on the y-axis) are a greater order of magnitude compared with observed benefits for both seeking and disseminating tendencies across all courses. Smaller courses are grouped among the courses with highest seeking and disseminating scores. However, larger courses, with thousands of students, also display high disseminating tendencies, suggesting a network effect where once a course reaches a certain size, disseminating behavior becomes more generalized and knowledge more accessible in a positive feedback loop.

Seeking and disseminating scores differ by orders of magnitude. Interestingly, seeking behavior is much less prevalent than disseminating behavior in MOOC discussion forums across all groups. The lower seeking scores can be understood by the fact that *seeking* here is defined in terms of question posting and ignores all the other ways individuals may seek information before resorting to asking a question in the discussion forum (e.g., asking a classmate or the instructor directly, searching in the course materials or using a search engine, etc.).

Table 2

Courses with Highest Seeking Tendency

Course	*N*	Seeking	Disseminating	Observed benefit	Optimized benefit
Networks: Friends, Money, and Bytes	68	1.16E-04	6.7675	9.5269	246.2457
Numerical Analysis	46	1.08E-04	2.9393	23.9728	17.3465
Computational Methods for Data Analysis	127	1.86E-05	0.8897	32.0250	26.2753
Physical Sciences	105	1.37E-05	1.7282	26.9862	364.8678
Digital Signal Processing	261	1.35E-05	0.9365	61.8857	908.1452
Precalculus	179	1.25E-05	1.2726	27.1547	197.1336
Asset Pricing	170	1.24E-05	0.7224	60.0251	49.7035
Compilers	221	1.09E-05	0.9093	76.1573	1,241.8557
Experimental Genome Science	176	9.40E-06	1.3903	24.4761	548.3799

Table 3

Courses with Highest Disseminating Tendency

Course	*N*	Seeking	Disseminating	Observed benefit	Optimized benefit
Data Structures and Algorithms	148	2.43E-06	29.2140	1.4256	2.4562
Introduction to Computing	418	3.01E-07	11.4953	4.7747	50.8587
Writing in Sciences	1691	1.10E-07	10.9102	12.9485	302.9709
Introduction to Psychology	4589	2.25E-08	9.3390	134.4230	6,656.4653
Networks: Friends, Money, and Bytes	68	1.16E-04	6.7675	9.5269	246.2457
History of Rock, Part One	524	3.66E-06	3.1643	28.5779	374.6067
Numerical Analysis	46	1.08E-	2.9393	23.9728	17.3465

		04			
Gamification	2431	8.28E-08	2.8050	32.8729	1,534.2317
Bioinformatics: Introduction and Methods	238	4.81E-06	2.3905	17.0457	171.7716
The Law of the European Union: An Introduction	831	6.60E-07	2.0681	64.8254	3,808.6908

Table 4

Courses with Highest Network Efficiency

Course	*N*	Seeking	Disseminating	Observed benefit	Optimized benefit
Startup Engineering	5172	1.64E-08	2.04	68.15	3,250.63
Machine Learning	4262	2.43E-08	1.41	57.09	1,901.45
Introduction to Data Science	3928	2.72E-08	1.38	59.11	2,520.50
Learn to Program: The Fundamentals	3042	3.59E-08	1.18	73.08	1,920.63
Statistics One	2953	4.76E-08	0.94	70.44	2,251.49
A Brief History of Humankind	2936	4.30E-08	0.63	199.30	3,329.09
Organizational Analysis	2623	8.76E-08	1.77	56.82	1,090.97
Gamification	2431	8.28E-08	2.81	32.87	1,534.23
Blended Learning: Personalizing Education for Students	1913	1.78E-07	1.99	152.56	3,435.24
The Fiction of Relationship	1851	8.55E-08	0.81	97.20	613.89

Figure 2

Network Efficiency by Observed Disseminating Tendency

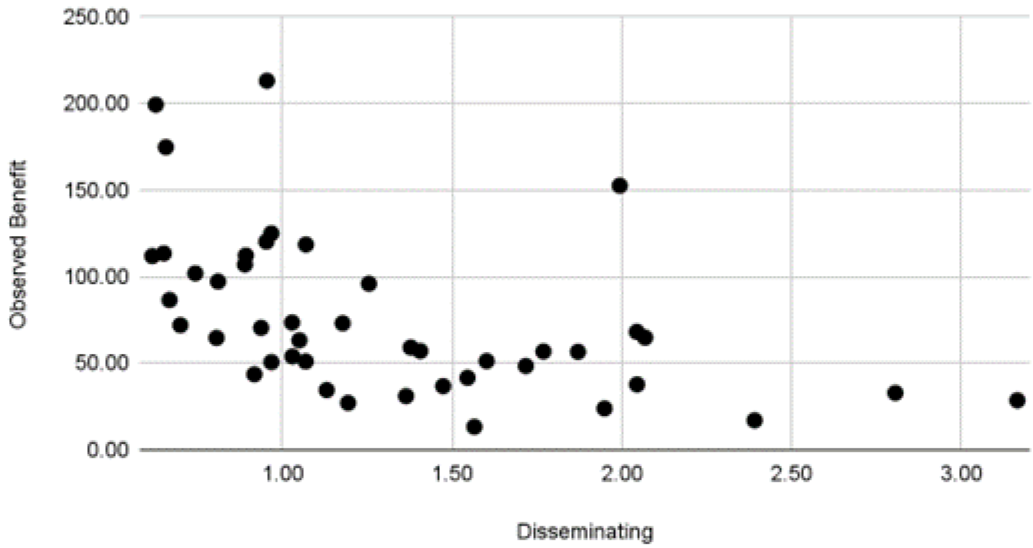


Figure 3

Network Efficiency by Optimized Disseminating Tendency

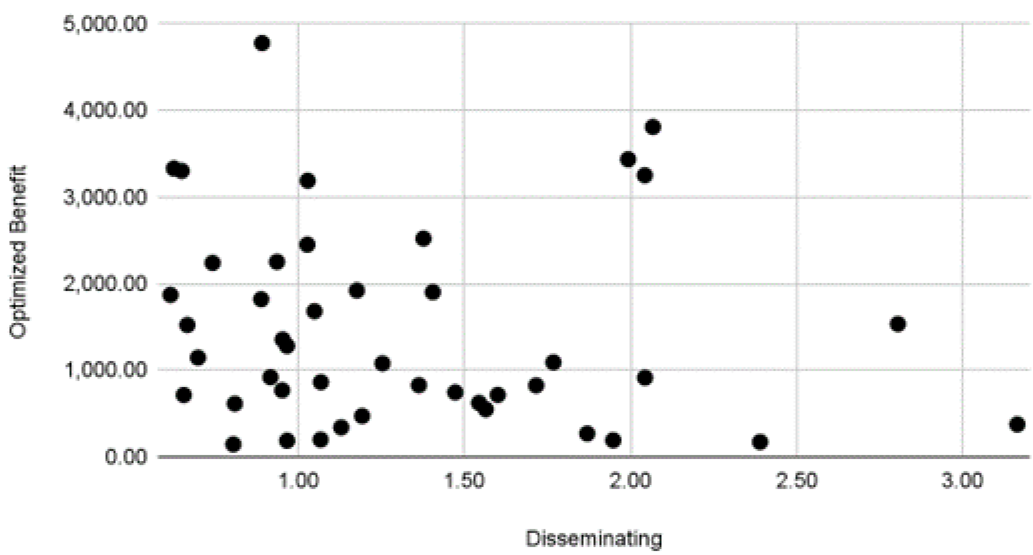


Figure 4

Network Efficiency by Observed Seeking Tendency

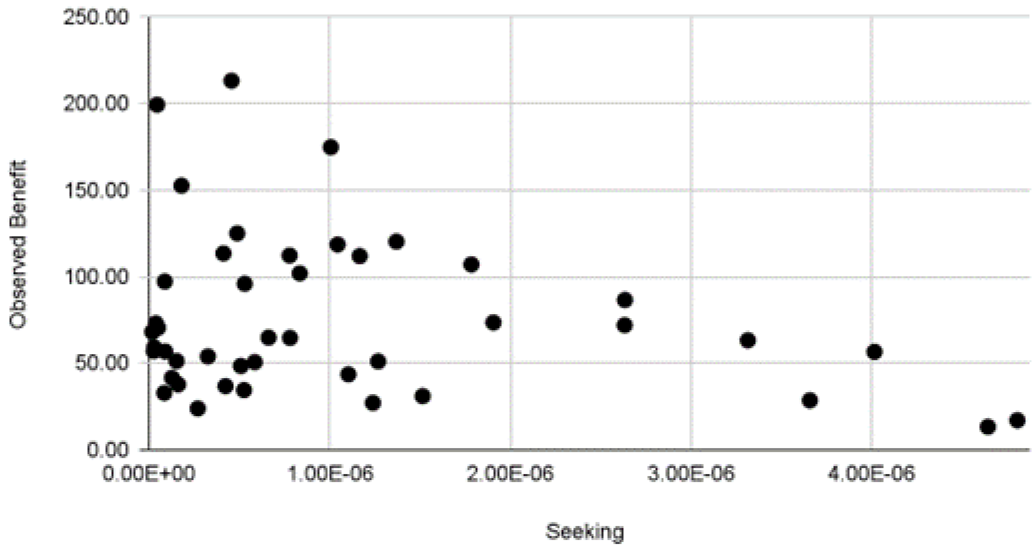
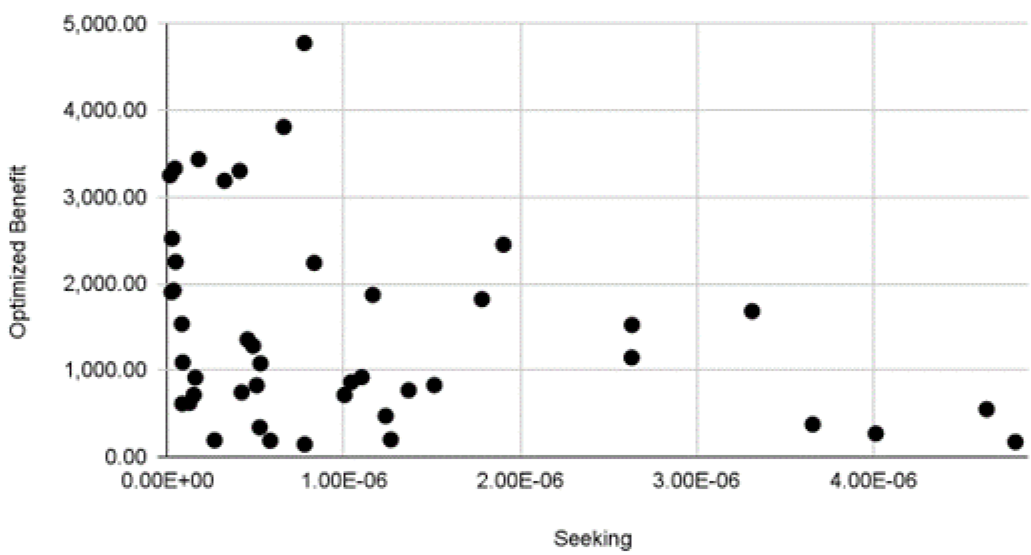


Figure 5

Network Efficiency by Optimized Seeking Tendency



Although the correlation coefficients revealed moderate effects, the statistics were not significant, as reported in Table 5.

Table 5

Pearson Correlation Coefficient for Seeking and Disseminating by Network Efficiency

Ratios	r	t	p
Seeking/observed	−0.2567	−2.0927	.1715
Seeking/optimized	−0.2785	−2.2995	.1482
Disseminating/observed	−0.2898	−2.4091	.1376
Disseminating/optimized	−0.2873	−2.3845	.1399

When comparing topics across courses, we found that courses made two broad uses of discussion forums: course-related and topic-related discussions. Some, like Blended Learning (Table 6) and Intro to European Union Law (Table 7), present topics that are more related to the subject matter. Others present topics that are more related to coursework. In Computational Methods (Table 8), we note an increased prevalence of course-directed words such as assignment, lecture, Coursera, and date.

Table 6

Subject-Related Talk: Blended Learning

Topic no.	Top word associations
0	Words: 0.029*“assign” + 0.020*“week” + 0.020*“video” + 0.016*“post” + 0.015*“link” + 0.015*“cours” + 0.014*“work” + 0.013*“final” + 0.013*“submit” + 0.013*“grade”
1	Words: 0.036*“thank” + 0.033*“cours” + 0.017*“think” + 0.015*“learn” + 0.012*“great” + 0.011*“share” + 0.010*“teach” + 0.009*“student” + 0.009*“good” + 0.009*“interest”
2	Words: 0.019*“student” + 0.018*“agre” + 0.014*“good” + 0.012*“learn” + 0.011*“definit” + 0.010*“teacher” + 0.009*“like” + 0.008*“peopl” + 0.008*“chang” + 0.008*“work”
3	Words: 0.032*“student” + 0.029*“teacher” + 0.022*“learn” + 0.018*“time” + 0.018*“think” + 0.017*“school” + 0.012*“work” + 0.010*“teach” + 0.007*“want” + 0.006*“like”
4	Words: 0.047*“learn” + 0.030*“student” + 0.019*“teacher” + 0.017*“blend” + 0.015*“think” + 0.015*“teach” + 0.013*“onlin” + 0.013*“time” + 0.011*“cours” + 0.009*“school”
5	Words: 0.041*“color” + 0.041*“size” + 0.040*“font” + 0.025*“think” + 0.019*“definit” + 0.016*“learn” + 0.014*“student” + 0.011*“khan” + 0.010*“like” + 0.009*“academi”
6	Words: 0.102*“learn” + 0.053*“student” + 0.038*“blend” + 0.016*“teacher” + 0.013*“high” + 0.013*“technolog” + 0.011*“qualiti” + 0.010*“person” + 0.010*“pace” + 0.009*“educ”
7	Words: 0.028*“learn” + 0.024*“student” + 0.020*“class” + 0.015*“technolog” + 0.013*“blend” + 0.012*“work” + 0.011*“like” + 0.011*“teach” + 0.010*“teacher” + 0.007*“school”
8	Words: 0.066*“student” + 0.018*“work” + 0.014*“learn” + 0.013*“teacher” + 0.012*“need” + 0.011*“group” + 0.010*“class” + 0.008*“classroom” + 0.008*“think” + 0.008*“like”

9	Words: 0.035*“learn” + 0.032*“school” + 0.027*“student” + 0.024*“teacher” + 0.018*“blend” + 0.015*“educ” + 0.011*“year” + 0.010*“work” + 0.009*“classroom” + 0.008*“teach”

Table 7

Subject-Related Talk: Intro to European Union Law—001

Topic no.	Top word associations
0	Words: 0.010*“cours” + 0.007*“state” + 0.006*“time” + 0.006*“peer” + 0.006*“think” + 0.005*“question” + 0.005*“like” + 0.005*“review” + 0.005*“thank” + 0.004*“great”
1	Words: 0.023*“state” + 0.018*“european” + 0.016*“member” + 0.011*“union” + 0.010*“countri” + 0.008*“europ” + 0.007*“market” + 0.007*“council” + 0.007*“econom” + 0.006*“treati”
2	Words: 0.018*“languag” + 0.011*“question” + 0.009*“think” + 0.008*“answer” + 0.008*“know” + 0.008*“countri” + 0.007*“european” + 0.007*“citizen” + 0.006*“peopl” + 0.006*“right”
3	Words: 0.018*“cours” + 0.011*“question” + 0.011*“direct” + 0.010*“case” + 0.010*“answer” + 0.009*“thank” + 0.009*“right” + 0.007*“point” + 0.007*“like” + 0.006*“good”
4	Words: 0.019*“state” + 0.015*“countri” + 0.013*“member” + 0.013*“right” + 0.011*“nation” + 0.011*“citizen” + 0.010*“case” + 0.009*“direct” + 0.008*“articl” + 0.008*“european”
5	Words: 0.013*“cours” + 0.010*“think” + 0.010*“learn” + 0.008*“peopl” + 0.008*“interest” + 0.007*“countri” + 0.007*“good” + 0.006*“time” + 0.006*“student” + 0.005*“like”
6	Words: 0.008*“peopl” + 0.008*“cours” + 0.008*“direct” + 0.007*“mean” + 0.007*“european” + 0.007*“think” + 0.007*“state” + 0.007*“ukrain” + 0.006*“work” + 0.006*“learn”
7	Words: 0.028*“cours” + 0.016*“week” + 0.013*“student” + 0.013*“read” + 0.011*“thank” + 0.011*“time” + 0.011*“video” + 0.009*“test” + 0.009*“think” + 0.009*“quiz”
8	Words: 0.014*“cours” + 0.012*“work” + 0.011*“countri” + 0.010*“live” + 0.009*“peopl” +

	0.009*"think" + 0.008*"differ" + 0.008*"good" + 0.008*"hello" + 0.007*"time"
9	Words: 0.027*"thank" + 0.009*"time" + 0.007*"book" + 0.007*"cours" + 0.006*"chegg" + 0.006*"problem" + 0.006*"answer" + 0.005*"final" + 0.005*"download" + 0.005*"like"

Table 8

Procedural Talk: Computational Methods

Topic no.	Top word associations
0	Words: 0.022*"cours" + 0.017*"frequenc" + 0.014*"time" + 0.009*"transform" + 0.009*"signal" + 0.009*"data" + 0.009*"function" + 0.009*"lectur" + 0.009*"think" + 0.008*"right"
1	Words: 0.027*"thank" + 0.021*"time" + 0.019*"frequenc" + 0.018*"plot" + 0.016*"domain" + 0.015*"point" + 0.011*"work" + 0.011*"grid" + 0.010*"wave" + 0.008*"number"
2	Words: 0.017*"matlab" + 0.014*"code" + 0.013*"imag" + 0.010*"filter" + 0.010*"slice" + 0.010*"problem" + 0.010*"fftshift" + 0.009*"subplot" + 0.008*"work" + 0.008*"meshgrid"
3	Words: 0.023*"time" + 0.014*"frequenc" + 0.014*"window" + 0.012*"cours" + 0.012*"domain" + 0.011*"answer" + 0.010*"signal" + 0.009*"function" + 0.008*"filter" + 0.006*"number"
4	Words: 0.018*"class" + 0.017*"plot" + 0.015*"forum" + 0.015*"thread" + 0.011*"coursera" + 0.011*"question" + 0.010*"compmethod" + 0.009*"thread_id" + 0.008*"like" + 0.008*"https"
5	Words: 0.019*"matlab" + 0.017*"thank" + 0.009*"valu" + 0.009*"know" + 0.009*"filter" + 0.008*"cours" + 0.008*"look" + 0.007*"right" + 0.007*"differ" + 0.007*"lectur"
6	Words: 0.024*"array" + 0.014*"plot" + 0.013*"octav" + 0.010*"like" + 0.009*"frac" + 0.008*"problem" + 0.007*"want" + 0.007*"line" + 0.007*"http" + 0.007*"function"
7	Words: 0.024*"frequenc" + 0.014*"nois" + 0.014*"imag" + 0.013*"signal" + 0.009*"time" +

	0.009*"https" + 0.009*"filter" + 0.008*"matlab" + 0.008*"lectur" + 0.008*"like"
8	Words: 0.018*"matlab" + 0.014*"valu" + 0.013*"frequenc" + 0.013*"time" + 0.011*"signal" + 0.010*"like" + 0.010*"function" + 0.009*"work" + 0.009*"domain" + 0.008*"fftshift"
9	Words: 0.020*"plot" + 0.018*"complex" + 0.016*"valu" + 0.014*"right" + 0.013*"leav" + 0.011*"real" + 0.011*"time" + 0.010*"nois" + 0.010*"domain" + 0.009*"signal"

Overall, SLOAN managed to find important efficiencies in the networks, over 90% for all but the two courses with the smallest population (< 200 students), in which global efficiency of the optimized network did not surpass 60%, and Introduction to Computing, with a score of 83%, which was an outlier with the maximum disseminating score of 11.50.

While SLOAN is very effective, often converging after a single iteration, it is subject to error when optimizing learning networks where the topics are not varied enough. We note five networks where the optimized solution was simply a fully connected network. In Table 9, we observe one such network solution for the Compilers course, where the topics are barely differentiated. Note the repeated occurrence of the same words across topics.

Table 9

Failed Optimization: Undifferentiated Topics, Compilers Course

Topic no.	Word associations
0	Words: 0.014*"state" + 0.013*"cours" + 0.013*"charact" + 0.012*"compil" + 0.011*"thank" + 0.009*"string" + 0.009*"work" + 0.009*"assign" + 0.008*"error" + 0.008*"understand"
1	Words: 0.023*"class" + 0.012*"return" + 0.012*"string" + 0.012*"cool" + 0.010*"case" + 0.010*"rule" + 0.010*"type" + 0.009*"express" + 0.009*"state" + 0.009*"symbol"
2	Words: 0.014*"work" + 0.012*"string" + 0.011*"program" + 0.010*"cach" + 0.009*"compil" + 0.009*"languag" + 0.008*"need" + 0.007*"good" + 0.007*"thank" + 0.006*"know"
3	Words: 0.020*"cours" + 0.016*"error" + 0.010*"compil" + 0.010*"pars" + 0.009*"class" + 0.009*"lectur" + 0.009*"assign" + 0.008*"test" + 0.008*"program" + 0.008*"wiki"
4	Words: 0.014*"error" + 0.012*"cours" + 0.011*"java" + 0.011*"class" + 0.010*"compil" + 0.010*"program" + 0.009*"like" + 0.009*"think" + 0.008*"rule" + 0.008*"start"
5	Words: 0.026*"compil" + 0.019*"cool" + 0.018*"class" + 0.018*"assign" + 0.012*"file" + 0.011*"program" + 0.011*"code" + 0.009*"lexer" + 0.008*"output" + 0.008*"line"
6	Words: 0.017*"state" + 0.014*"step" + 0.011*"class" + 0.011*"input" + 0.010*"thank" + 0.009*"think" + 0.009*"epsilon" + 0.008*"work" + 0.007*"script" + 0.007*"assign"
7	Words: 0.019*"class" + 0.015*"work" + 0.013*"expr" + 0.011*"code" + 0.010*"express"

	+ 0.009*“look” + 0.009*“languag” + 0.008*“rule” + 0.008*“like” + 0.008*“method”
8	Words: 0.027*“thank” + 0.024*“string” + 0.014*“rule” + 0.011*“error” + 0.009*“charact” + 0.009*“problem” + 0.008*“like” + 0.008*“return” + 0.008*“match” + 0.007*“token”
9	Words: 0.016*“express” + 0.010*“cool” + 0.010*“time” + 0.009*“string” + 0.009*“assign” + 0.008*“exampl” + 0.008*“line” + 0.008*“thank” + 0.007*“token” + 0.007*“like”

Finally, we compared courses where talk was dominated by procedural matters—assignment questions, lecture notes, quizzes—with courses where the talk was dominated by subject-related matters—that is, centered on course topics (Table 10). After removing outliers and non-English courses, we calculated the *t*-statistic for both groups and found they were significantly different on seeking tendency though not on disseminating tendency, as well as significantly different on observed and optimized network efficiency.

Table 10

Differences Between Procedural and Subject-Related Talk

	t-statistic	*P-value*
Observed network efficiency		
Procedural talk	0.00E+00	0.022094755160
Subject-related talk	0.00E+00	
Optimized network efficiency		
Procedural talk	0.00E+00	0.044738732610
Subject-related talk	0.00E+00	
Seeking		
Procedural talk	1.00E+00	0.001951708988
Subject-related talk	1.00E+00	
Disseminating		
Procedural talk	2.92E-01	0.552466099200
Subject-related talk	3.39E-01	

Discussion

We conducted a social learning optimization analysis of networks (SLOAN) in MOOC discussion forums in 60 Coursera MOOCs. We found that MOOC forums differ in terms of the optimization potential. Courses with smaller enrollment numbers appear to struggle more with generating enough discussion and connecting knowledge seekers with knowledge disseminators. However, we find that networks of all sizes can be optimized to improve their overall efficiency. Most interesting of all, we find that subject-related-talk-dominated discussion forums and procedural-talk-dominated discussion forums are significantly different in overall network efficiency and seeking tendency, but not in disseminating tendency.

It is striking how seeking tendency is orders of magnitude lower than disseminating tendency. This is possibly due to the nature of the discourse in the discussion forums, where learners are sharing information but not necessarily engaging extensively and collectively in discussion but rather are engaging in smaller sporadic exchanges. It may also be because knowledge seeking and knowledge disseminating are functions of question-asking tendency; this ignores the many other ways that knowledge-seeking behavior can manifest itself in a forum, such as composing a search query or simply reading through posts. Indeed, researchers have demonstrated that a range of online discussion behaviors are associated with differential learning outcomes (Almatrafi & Johri, 2019; O'Riordan et al., 2020; Wise et al., 2014). As one of the few studies of a larger sample of MOOC forums (Rossi & Gnawali, 2014), we find that these differences can be explained in part by the different uses made of discussion forums for MOOC learning. Wise and colleagues (Wise, 2018; Wise et al., 2017) have compared course-related and non-course-related discussion in MOOC discussion forums. They did not find significant differences in learning outcomes based on their analysis; however, they admitted this could be due to their analytical scheme. In contrast, we found significant differences in disseminating behavior between courses with a greater focus on subject versus procedural talk in the MOOC discussion forums.

Social network analysis has been applied extensively to the study of online learning (Jan et al., 2019). However, much of this research has not considered the quality of connections in social graph, such as, assessing the informativeness of the connections in a social learning network; although interaction patterns are quite variable and are not all equally conducive to learning (O'Riordan et al., 2020; Wise et al., 2017). Our study shows that content and connections can be reconciled, and these complex, multivariate interactions can be modeled and optimized using advanced numerical techniques. Integrating social learning analysis with content analysis in such a fashion provides quantitative tools for studying and augmenting social learning in technology-supported environments in the wild.

Implications

In the present study, we have argued for conducting educational technology research in the learning interface (Duchastel, 1996), that is, developing algorithms and technologies that augment human intellectual activity (Engelbart, 1962) through responsive and adaptive tools that support and extend our abilities. We have presented a novel approach to conducting educational technology research using optimization theory to maximize learning through online discussion forums. We believe that optimization research holds much promise for the field of educational technology and distance/online learning research. It aligns with the design experimentation ethos (Brown, 1992; Cobb et al., 2003) as it is also concerned with improving teaching and learning through iterative innovation. It is suited to constructivist-based research

(Lemay & Doleck, 2020) with its sociocultural focus on tools as social artifacts and its central place in human social activity (Gee & Green, 1998). Optimization theory is being applied to improve tools and methods in data-intensive disciplines such as neuroscience, where it is helping to improve neural interfaces (Fathima & Kore, 2021). As we have shown, optimization theory can also help improve the learning interface. Online and distance learning have well-established research traditions and well-developed instructional theories such as communities of inquiry (Garrison & Akyol, 2012) and computer-supported collaborative learning (Koshmann, 2011). Interface tools like SLOAN can help improve knowledge sharing and discovery in online learning platforms.

The current study also has implications for discussions in other settings and contexts beyond MOOCs. Such an optimization algorithm can be applied to any information tool that incorporates knowledge-sharing mechanisms, such as Slack or Microsoft Teams in the workplace, to help support knowledge discovery and synergy.

Limitations

The present study is limited by its use of a convenience sample; however, we believe that this is mitigated by its range and its relative size, considering most studies consider few forums in their investigations. This study is also limited by its quasi-experimental nature. We did not conduct an experiment and cannot conclude any causal relationships; however, we believe this exploratory research shows SLOAN's potential for interventionist study and particularly the potential benefits of SLOAN for social learning in online discussion forums in general and in MOOCs in particular. Given the unequal distribution of courses in our convenience sample, we did not make disciplinary comparisons. However, it is possible that disciplinary features led to systematic differences in discussion forum uses.

Conclusions and Future Directions

Online social learning is quickly becoming an indispensable part of learning at every stage and in every environment, from schools to workplaces and into our daily life. The Internet is a great repository of knowledge, but it is primarily a tool for leveraging our collective wisdom. This has been facilitated by specialized knowledge-sharing forums for particular user communities, such as StackExchange and StackOverflow, and by more general knowledge-sharing platforms, such as Quora for questions and answers and Reddit for interest groups. However, the creation of filter bubbles (Turkle, 2010) has shown the dangers of ill-moderated online discussion. We believe that the best way to counter misinformation and intolerance is through discussion for knowledge and perspective sharing. Tools that can optimize social learning online can have multiplicative effects: as people learn to harness the power of online social learning networks, their agency is increased and potentials are extended (Bandura, 2001). Given the polarized landscape and the poor level of much online discourse, fostering better online discourse appears to be a moral imperative.

References

Almatrafi, O., & Johri, A. (2019). Systematic review of discussion forums in massive open online courses (MOOCs). *IEEE Transactions on Learning Technologies*, *12*(3), 413–428. https://doi.org/10.1109/tlt.2018.2859304

Andresen, M. A. (2009). Asynchronous discussion forums: Success factors, outcomes, assessments, and limitations. *Educational Technology & Society*, *12*(1), 249–257. https://www.researchgate.net/publication/220374740_Asynchronous_Discussion_Forums_Success_Factors_Outcomes_Assessments_and_Limitations

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1-26. https://doi.org/10.1146/annurev.psych.52.1.1

Bergner, Y., Kerr, D., & Pritchard, D. E. (2015, June 26–29). Methodological challenges in the analysis of MOOC data for exploring the relationship between discussion forum views and learning outcomes. In *EDM '15: Proceedings of the 8th International Conference on Educational Data Mining* (pp. 234–241). International Educational Data Mining Society. https://files.eric.ed.gov/fulltext/ED560510.pdf

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of Machine Learning Research, 3*, 993-1022. https://www.jmlr.org/papers/volume3/blei03a/blei03a.pdf

Boroujeni, M. S., Hecking, T., Hoppe, H. U., & Dillenbourg, P. (2017, March). Dynamics of MOOC discussion forums. In *LAK '17: Proceedings of the Seventh International Learning Analytics & Knowledge Conference* (pp. 128–137). Association for Computing Machinery. https://doi.org/10.1145/3027385.3027391

Boyd, S., & Vandenberghe, L. (2004). *Convex optimization*. Cambridge University Press. https://doi.org/10.1017/CBO9780511804441

Brinton, C. G., Buccapatnam, S., Wong, F. M. F., Chiang, M., & Poor, H. V. (2016, April 10–14). *Social learning networks: Efficiency optimization for MOOC forums*. IEEE INFOCOM 2016—The 35th Annual IEEE International Conference on Computer Communications, San Francisco, CA. https://doi.org/10.1109/INFOCOM.2016.7524579

Brinton, C. G., Buccapatnam, S., Zheng, L., Cao, D., Lan, A. S., Wong, F. M. F., Ha, S., Chiang, M., & Poor, H. V. (2018). On the efficiency of online social learning networks. *IEEE/ACM Transactions on Networking*, *26*(5), 2076–2089. https://doi.org/10.1109/TNET.2018.2859325

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*(2), 141–178. https://doi.org/10.1207/s15327809jls0202_2

Castañeda, L., & Williamson, B. (2021). Assembling new toolboxes of methods and theories for innovative critical research on educational technology. *Journal of New Approaches in Educational Research*, *9*(2), 1–14. https://doi.org/10.7821/naer.2021.1.703

Castro, M., & Tumibay, G. (2019). A literature review: Efficacy of online learning courses for higher education institution using meta-analysis. *Education and Information Technologies*, *26*, 1367–1385. https://doi.org/10.1007/s10639-019-10027-zhttps://doi.org/10.1007/s10639-019-10027-z

Chiu, T. K., & Hew, T. K. (2018). Factors influencing peer learning and performance in MOOC asynchronous online discussion forum. *Australasian Journal of Educational Technology, 34*(4), 16-28. https//doi.org/10.14742/ajet.3240

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9–13. https://doi.org/10.3102/0013189X032001009

Crittenden, W. (2005). A social learning theory of cross-functional case education. *Journal of Business Research*, *58*(7), 960–966. https://doi.org/10.1016/j.jbusres.2003.12.005

Deaton, S. (2015). Social learning theory in the age of social media: Implications for educational practitioners. *I-Manager's Journal of Educational Technology*, *12*(1), 1–6. https://doi.org/10.26634/jet.12.1.3430

Dehmer, M. and Mowshowitz, A. (2011). Generalized graph entropies. *Complexity, 17*(2) 45-50.

Doleck, T., Lemay, D. J., & Brinton, C. G. (2021). Evaluating the efficiency of social learning networks: Perspectives for harnessing learning analytics to improve discussions. *Computers & Education*, *164*, Article 104124. https://doi.org/10.1016/j.compedu.2021.104124

Dowell, N. M., Skrypnyk, O., Joksimovic, S., Graesser, A. C., Dawson, S., Gasevic, D., Hennis, T. A., de Vries, P., & Kovanovic, V. (2015, June 26–29). Modeling learners' social centrality and performance through language and discourse. In *EDM '15: Proceedings of the 8th International Conference on Educational Data Mining* (pp. 250–257). International Educational Data Mining Society. https://files.eric.ed.gov/fulltext/ED560532.pdf

Duchastel, P. (1996). Learning interfaces. In T. Liao (Ed.), *Advanced educational technology: Research issues and future potential* (pp. 206–217). Springer. https://doi.org/10.1007/978-3-642-60968-8_13

Engelbart, D. C. (1962, October) Augmenting Human Intellect: A Conceptual Framework. SRI Sumary Report AFOSR-3223. Prepared for: Director of Information Sciences, Air Force Office of Scientific Research, Washington DC, Contract AF 49(638)-1024. SRI Project No. 3578.

Fathima, S., & Kore, S. K. (2021). Formulation of the challenges in brain–computer interfaces as optimization problems—a review. *Frontiers in Neuroscience*, *14*, Article 546656. https://doi.org/10.3389/fnins.2020.546656

Feng, Y., Chen, D., Zhao, Z., Chen, H., & Xi, P. (2015, August). The impact of students and TAs' participation on students' academic performance in MOOC. In J. Pei, F. Silvestri., & J. Tang (Eds.), *Proceedings of the 2015 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining 2015* (pp. 1149–1154). Association for Computing Machinery. https://doi.org/10.1145/2808797.2809428

Fu, E. L. F., van Aalst, J., & Chan, C. K. K. (2016). Toward a classification of discourse patterns in asynchronous online discussions. *International Journal of Computer-Supported Collaborative Learning*, *11*, 441–478. https://doi.org/10.1007/s11412-016-9245-3

Galikyan, I., Admiraal, W., & Kester, L. (2021). MOOC discussion forums: The interplay of the cognitive and the social. *Computers & Education*, *165,* Article 104133. https://doi.org/10.1016/j.compedu.2021.104133

Gardner, J., & Brooks, C. (2018). Student success prediction in MOOCs. *User Modeling and User-Adapted Interaction*, *28*(2), 127–203. https://doi.org/10.1007/s11257-018-9203-z

Garrison, D., & Akyol, Z. (2012). The Community of Inquiry theoretical framework. In M. G. Moore (Ed.), *Handbook of distance education* (3rd ed., pp. 104–120). Taylor & Francis. https://doi.org/10.4324/9780203803738.ch7

Gay, G. H., & Betts, K. (2020). From discussion forums to eMeetings: Integrating high touch strategies to increase student engagement, academic performance, and retention in large online courses. *Online Learning*, *24*(1), 92–117. https://files.eric.ed.gov/fulltext/EJ1249245.pdf

Gee, J. P., & Green, J. L. (1998). Chapter 4: Discourse analysis, learning, and social practice: A methodological study. *Review of Research in Education, 23*(1), 119–169. https://doi.org/10.3102/0091732X023001119

Gilbert, P., & Dabbagh, N. (2004). How to structure online discussions for meaningful discourse: A case study. *British Journal of Educational Technology*, *36*(1), 5–18. https://doi.org/10.1111/j.1467-8535.2005.00434.x

Goshtasbpour, F., Swinnerton, B., & Pickering, J. (2021). Twelve tips for engaging learners in online discussions. *Medical Teacher*, *44*(3), 244–248. https://doi.org/10.1080/0142159x.2021.1898571

Hammond, M. (2005). A review of recent papers on online discussion in teaching and learning in higher education. *Journal of Asynchronous Learning Networks*, *9*(3), 9–23. https://doi.org/10.24059/olj.v9i3.1782

Hill, J., Song, L. and West, R. (2009). Social learning theory and web-based learning environments: A review of research and discussion of implications. *American Journal of Distance Education, 23*(2), 88-103. https://doi.org/10.1080/08923640902857713

Jan, S. K., Vlachopoulos, P., & Parsell, M. (2019). Social network analysis and learning communities in higher education online learning: A systematic literature review. *Online Learning Journal*, *23*, 249–264. https://doi.org/10.24059/olj.v23i1.1398

Jiang, S., Fitzhugh, S.M., & Warschauer, M. (2014). Social positioning and performance in MOOCs. EDM.

Joksimović, S., Manataki, A., Gašević, D., Dawson, S., Kovanović, V., & De Kereki, I. F. (2016). Translating network position into performance: importance of centrality in different network configurations. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge (pp.314-323)*. ACM.

Joksimović, S., Poquet, O., Kovanović, V., Dowell, N., Mills, C., Gašević, D., Dawson, S., Graesser, A. C., & Brooks, C. (2017). How do we model learning at scale? A systematic review of research on MOOCs. *Review of Educational Research*, *88*(1), 43–86. https://doi.org/10.3102/0034654317740335

Kim, M. K., & Ketenci, T. (2019). Learner participation profiles in an asynchronous online collaboration context. *The Internet and Higher Education*, *41*, 62–76. https://doi.org/10.1016/j.iheduc.2019.02.002

Kimmons, R., Rosenberg, J., & Allman, B. (2021). Trends in educational technology: What Facebook, Twitter, and Scopus can tell us about current research and practice. *TechTrends*, *65*(2), 125–136. https://doi.org/10.1007/s11528-021-00589-6

Kloos, C. D., Alario-Hoyos, C., Muñoz-Merino, P. J., Ibáñez, M. B., Estévez-Ayres, I., & Fernández-Panadero, C. (2020). Educational technology in the age of natural interfaces and deep learning. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, *15*(1), 26–33. https://doi.org/10.1109/RITA.2020.2979165

Koschmann, T. D. (2011). *Theories of learning and studies of instructional practice*. Springer.

Latora, V., & Marchiori, M. (2001). Efficient behavior of small-world networks. *Physical Review Letters*, *87*(19), Article 198701. https://doi.org/10.1103/PhysRevLett.87.198701

Lee, J. and Recker, M., 2021. The effects of instructors' use of online discussions strategies on student participation and performance in university online introductory mathematics courses. *Computers & Education, 162*, 104084.

Lemay, D. J., & Doleck, T. (2020). Constructivist educational technology: Re-examining the foundations and state of the literature. *British Journal of Educational Technology, 51*(6), 1905-1906. https//doi.org/10.1111/bjet.13042

Lemay, D. J., Doleck, T., & Bazelais, P. (2021). Transition to online teaching during the COVID-19 pandemic. *Interactive Learning Environments*, 1-12. https//doi.org/10.1080/10494820.2021.1871633

Liao, T. (1996). *Advanced educational technology: Research issues and future potential*. Springer.

Loizzo, J., & Ertmer, P. (2016). MOOCocracy: The learning culture of massive open online courses. *Educational Technology Research and Development*, *64*, 1013–1032. https://doi.org/10.1007/s11423-016-9444-7

Marra, R. (2006). A review of research methods for assessing content of computer-mediated discussion forums. *Journal of Interactive Learning Research*, *17*(3), 243–267. https://www.learntechlib.org/primary/p/6290/

Marx, K. (1973). Fragment on the machines. In *Grundrisse: Foundations of the critique of political economy* (M. Nicolaus, Trans.; ch. 13). Marxists Internet Archive. https://www.marxists.org/archive/marx/works/1857/grundrisse/ch13.htm (Original work published 1939–1941)

Moore, R., Yen, C., & Powers, F. (2020). Exploring the relationship between clout and cognitive processing in MOOC discussion forums. *British Journal of Educational Technology*, *52*(1), 482–497. https://doi.org/10.1111/bjet.13033

O'Riordan, T., Millard, D., & Schulz, J. (2020). Is critical thinking happening? Testing content analysis schemes applied to MOOC discussion forums. *Computer Applications in Engineering Education*, *29*(4), 690–709. https://doi.org/10.1002/cae.22314

Raković, M., Marzouk, Z., Liaqat, A., Winne, P. H., & Nesbit, J. C. (2020). Fine grained analysis of students' online discussion posts. *Computers & Education*, *157*, Article 103982. https://doi.org/10.1016/j.compedu.2020.103982

Reed, M. S., Evely, A. C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond C., & Stringer, L. C. (2010). What is social learning? *Ecology and Society*, *15*(4), Article r1. http://www.ecologyandsociety.org/vol15/iss4/resp1/

Rosé, C. (2017). Discourse analytics. In C. Lang, G. Siemens, A. F. Wise, & D. Gaevic (Eds.), *Handbook of learning analytics* (pp. 105–114). Society for Learning Analytics Research (SoLAR). https://doi.org/10.18608/hla17.009

Rosé, C., Wang, Y., Cui, Y., Arguello, J., Stegmann, K., Weinberger, A. and Fischer, F.(2008). Analyzing collaborative learning processes automatically: Exploiting the advances of computational linguistics in computer-supported collaborative learning. *International Journal of Computer-Supported Collaborative Learning, 3*(3), 237-271. https://doi.org/10.1007/s11412-007-9034-0

Rossi, L. A., & Gnawali, O. (2014, August 13–15). Language independent analysis and classification of discussion threads in Coursera MOOC forums. In J. Joshi, E. Bertino, B. Thuraisingham, & L. Liu (Eds.), *Proceedings of the IEEE International Conference on Information Reuse and Integration (IEEE IRI 2014)* (pp. 654–661). IEEE Systems, Man, and Cybernetics Society (SMC). https://doi.org/10.1109/IRI.2014.7051952

Rovai, A. (2007). Facilitating online discussions effectively. *The Internet and Higher Education*, *10*(1), 77–88. https://doi.org/10.1016/j.iheduc.2006.10.001

Ruipérez-Valiente, J., Halawa, S., Slama, R., & Reich, J. (2020). Using multi-platform learning analytics to compare regional and global MOOC learning in the Arab world. *Computers & Education*, *146*, Article 103776. https://doi.org/10.1016/j.compedu.2019.103776

Santos, J. L., Klerkx, J., Duval, E., Gago, D., & Rodríguez, L. (2014, March). Success, activity and drop-outs in MOOCs an exploratory study on the UNED COMA courses. In *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge* (pp. 98–102). Association for Computing Machinery. https://doi.org/10.1145/2567574.2567627

Scardamalia, M., & Bereiter, C. (2014). Knowledge building and knowledge creation: Theory, pedagogy, and technology. In R. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 397–417). Cambridge University Press. https://doi.org/10.1017/CBO9781139519526.025

Soter, A. O., Wilkinson, I. A., Murphy, P. K., Rudge, L., Reninger, K., & Edwards, M. (2008). What the discourse tells us: Talk and indicators of high-level comprehension. *International Journal of Educational Research*, *47*(6), 372–391. https://doi.org/10.1016/j.ijer.2009.01.001

Tang, H., Xing, W., & Pei, B. (2018). Exploring the temporal dimension of forum participation in MOOCs. *Distance Education*, *39*(3), 353–372. https://doi.org/10.1080/01587919.2018.1476841

Thomas, M. (2002). Learning within incoherent structures: The space of online discussion forums. *Journal of Computer Assisted Learning*, *18*(3), 351–366. https://doi.org/10.1046/j.0266-4909.2002.03800.x

Tirado, R., Hernando, A., & Aguaded, J. I. (2012). The effect of centralization and cohesion on the social construction of knowledge in discussion forums. *Interactive Learning Environments*, *23*(3), 293–316. https://doi.org/10.1080/10494820.2012.745437

Tseng, S., Tsao, Y., Yu, L., Chan, C., & Lai, K. (2016). Who will pass? Analyzing learner behaviors in MOOCs. *Research and Practice in Technology Enhanced Learning*, *11*, Article 8. https://doi.org/10.1186/s41039-016-0033-5

Turkle, S. (2011). *Alone together: Why we expect more from technology and less from each other*. Basic Books.

Vygotsky. L. S. (1986). *Thought and language*. MIT Press. https://mitpress.mit.edu/books/thought-and-language

Wang, X., Yang, D., Wen, M., Koedinger, K., & Rosé, C. P. (2015, June 26–29). Investigating how student's cognitive behavior in MOOC discussion forums affect learning gains. In *EDM '15: Proceedings of the 8th International Conference on Educational Data Mining* (pp. 226–233). International Educational Data Mining Society. https://files.eric.ed.gov/fulltext/ED560568.pdf

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Harvard University Press. https://www.hup.harvard.edu/catalog.php?isbn=9780674943513

Winne, P. (2017). Learning analytics for self-regulated learning. In C. Lang, G. Siemens, A. F. Wise, & D. Gaevic (Eds.), *Handbook of learning analytics* (pp. 241–249). Society for Learning Analytics Research (SoLAR). https://doi.org/10.18608/hla17.021

Wise, A. F., Azevedo, R., Stegmann, K., Malmberg, J., Rosé, C. P., Mudrick, N., Taub, M., Martin, S. A., Farnsworth, J., Mu, J., Järvenoja, H., Järvelä, S., Wen, M., Yang, D., & Fischer, F. (2015). CSCL and learning analytics: Opportunities to support social interaction, self-regulation and socially shared regulation. In *CSCL 2015 Proceedings* (pp. 607–614). International Society of the Learning Sciences.

Wise, A & Cui, Y. (2018). Unpacking the relationship between discussion forum participation and learning in MOOCs: content is key. In *Proceedings of the 8th International Conference on Learning Analytics and Knowledge* (pp.330-339). Association for Computing Machinery. https//doi.org/10.1145/3170358.3170403

Wise, A. F., Cui, Y., Jin, W., & Vytasek, J. (2017). Mining for gold: Identifying content-related MOOC discussion threads across domains through linguistic modeling. *The Internet and Higher Education*, *32*, 11–28, https://doi.org/10.1016/j.iheduc.2016.08.001

Wise, A., Hausknecht, S. and Zhao, Y., (2014). Attending to others' posts in asynchronous discussions: Learners' online "listening" and its relationship to speaking. *International Journal of Computer-Supported Collaborative Learning*, *9*(2), 185-209. https://doi.org/10.1007/s11412-014-9192-9

Wu, D., & Hiltz, S. (2004). Predicting learning from asynchronous online discussions. *Journal of Asynchronous Learning Networks*, *8*(2), 139–152. https://doi.org/10.24059/olj.v8i2.1832

Zhu, M., Bergner, Y., Zhang, Y., Baker, R., Wang, Y., & Paquette, L. (2016, April 25–29). Longitudinal engagement, performance, and social connectivity: A MOOC case study using exponential random graph models. In *LAK '16, Proceedings of the Sixth International Conference on Learning Analytics & Knowledge* (pp. 223–230). Association for Computing Machinery. https://doi.org/10.1145/2883851.2883934

Zhu, M., Sari, A., & Lee, M. (2020). A comprehensive systematic review of MOOC research: Research techniques, topics, and trends from 2009 to 2019. *Educational Technology Research and Development*, *68*(4), 1685–1710. https://doi.org/10.1007/s11423-020-09798-x

Zou, W., Hu, X., Pan, Z., Li, C., Cai, Y. and Liu, M. (2021). Exploring the relationship between social presence and learners' prestige in MOOC discussion forums using automated content analysis and social network analysis. *Computers in Human Behavior, 115,* Article 106582. https://doi.org/10.1016/j.chb.2020.106582

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A Learning Analytics Approach Using Social Network Analysis and Binary Classifiers on Virtual Resource Interactions for Learner Performance Prediction

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Abstract

The COVID-19 pandemic induced a digital transformation of education and inspired both instructors and learners to adopt and leverage technology for learning. This led to online learning becoming an important component of the new normal, with home-based virtual learning an essential aspect for learners on various levels. This, in turn, has caused learners of varying levels to interact more frequently with virtual resources to supplement their learning. Even though virtual learning environments provide basic resources to help monitor the learners' online behaviour, there is room for more insights to be derived concerning individual learner performance. In this study, we propose a framework for visualising learners' online behaviour and use the data obtained to predict whether the learners would clear a course. We explored a variety of binary classifiers from which we achieved an overall accuracy of 80%–85%, thereby indicating the effectiveness of our approach and that learners' online behaviour had a significant effect on their academic performance. Further analysis showed that common patterns of behaviour among learners and/or anomalies in online behaviour could cause incorrect interpretations of a learner's performance, which gave us a better understanding of how our approach could be modified in the future.

Keywords: social network analysis, machine learning, binary classifiers, supervised and ensemble learning algorithms, virtual resources interactions, learners' academic performance

A Learning Analytics Approach Using Social Network Analysis and Binary Classifiers on Virtual Resource Interactions for Learner Performance Prediction

Virtual learning environments (VLE) have replaced physical classrooms in various institutions and have been widely adopted by instructors and learners of various levels worldwide due to the COVID-19 pandemic. The resources provisioned by course providers and/or instructors in these environments are used to supplement learners' learning and/or assess their understanding of the course material they have been taught up to a certain point in time. Virtual resources contribute to a learner's academic performance in educational institutions worldwide. Therefore, learners' behaviour within an online environment, for example, how they interact with such virtual resources, could help us study whether any correlation exists between their online activity and their performance in a course. Learning behaviour can be examined with the application of big data techniques to promote learner success (Khor and Looi, 2019). Hence, the purpose of this study was to model the behaviours of learners in a VLE and explore whether we could leverage big data techniques and use learners' interactions with virtual learning resources to predict whether a learner is successful in clearing a course, thereby helping us to understand how their behaviour in a virtual environment affects their academic achievement.

Social network analysis (SNA) is a means to examine social structures with the aid of networks and graph theory (Grunspan et al., 2014; Otte & Rousseau, 2002). The structures, commonly referred to as sociograms, are analysed with nodes as points, representing people or other entities of interest in the network, and ties or edges as lines, which are usually relationships or interactions between the entities. This method of visualising social structures allows us to quantitatively and qualitatively analyse them to derive valuable insights. SNA has been applied in education research to examine how learners form relationships through learning and how these relationships affect their learning outcomes. For example, SNA has been applied to understand the structure of the study networks formed between learners in an undergraduate class and how it could ultimately influence individual learners' academic performance (Grunspan et al., 2014). On the other hand, Rabbany et al. (2012) have applied SNA to understand learner interactions where social mining and other SNA techniques were exploited to discover structures in the network graphs generated from the manner and content of interactions between the learners. The study provides instructors with insight to better visualise the interactions among the learners, have a better understanding of the main influencers, and give them a better understanding of learner participation, especially with courses that rely on virtual resources.

Chung and Paredes (2015) have developed a social network model for online learning and performance. The authors analysed social learning in an e-learning environment and used SNA to demonstrate how the properties of a learner's social network, along with the learner's contribution towards the learning of others and the content of their contribution, impact the learning and performance of others. Meanwhile, Dragulescu et al. (2015) make use of various tools to query the social interactions from various data sources and run SNA on the queries to show it can be used to model the interactions using data from a pool of resources.

A study conducted by Saqr et al. (2018) shows how online interaction data can be collated and processed in order to use SNA to study how collaboration between peers in a course influences performance. Furthermore, Rakic et al. (2018) explore how SNA can be used to study and analyse the use of virtual resources on an e-learning platform to find vital indicators of learner performance in different courses. Rakic et al. (2019, 2020) further developed this study by using SNA with other machine learning methods. In all these studies, the use of resources on the e-learning platform was found to contribute significantly to a learner's performance.

Learning analytics, along with machine learning, has been applied to an assortment of institutions' VLE data to help predict learner performance and understand factors affecting it. Koza et al. (1996) and Mitchell (1997) describe machine learning as the construction and usage of algorithms that leverage data to make predictions or decisions and improve performance in the automation of specific tasks.

The most basic approaches in machine learning make use of either supervised or unsupervised learning. For predictive tasks or data classification, supervised learning makes use of labelled data to train algorithms to learn how to predict outcomes or classify the data, while unsupervised learning finds patterns within unlabelled data to learn how to cluster or split the data into different groups. Ensemble techniques in either supervised or unsupervised learning use various learning algorithms to improve predictive or classification performance compared with that obtained with just a single supervised or unsupervised learning algorithm. The machine learning approach to be used in a task is based on the objective and the data that has been made available.

Wolff et al. (2013) have leveraged learning analytics methods to develop models to predict at-risk learners based on their behaviour within VLEs and their demographic data. Al-Azawei and Al-Masoudy (2020) have also developed a predictive model that used behavioural data from VLEs along with assessment scores and demographic data to predict academic performance. Clickstream data from the VLE can also be used to predict at-risk learners with the application of deep learning techniques (Waheed et al. 2020).

Rivas et al. (2021) employ machine learning to understand the key factors behind a learner's performance, while Agudo-Peregrina et al. (2012) use learning analytics to study the different types of interactions within a VLE and how each type of interaction influences the academic performance of the learners. Mariame, et al. (2021) also show how machine learning can be used to find the best features for predicting learner performance; de Barba et al. (2016) use learning analytics and data mining to show how motivation and participation were key contributors to learners' performance in an online course.

Sekeroglu et al. (2019) combine educational data mining and machine learning algorithms to effectively predict and classify the academic performance of learners. The results of the study indicate that performance can be improved by experimenting with different types of features and algorithms. Albreiki et al. (2021) also use these techniques on data from e-learning platforms to study how effective it is in identifying learners who need assistance and/or who had the potential to drop out.

SNA, together with educational data mining, has also been leveraged to assess how learner interactions through various communication networks impacted learning as well as performance. For example, Mastoory et al. (2016) focus on the impact of communication and behaviour networks and how they affect a learner's academic performance. Their study also shows how communication networks play a vital role in predicting a learner's performance.

Although all these studies have shown how SNA and machine learning have been used individually to analyse and/or predict learner behaviour, more could be done to demonstrate how beneficial it would be to combine both techniques. This may not only help us effectively predict learner academic performance but also potentially give us more insights into what factors influence learner performance. Therefore, this study's aim was to apply and examine the efficacy of a framework where SNA is applied to visualise and analyse learners' interactions with virtual resources in the Open University Learning Analytics Dataset (OULAD; Kuzilek et al., 2017), and the insights obtained from it are used to predict learners' academic performance with the application of machine learning techniques. With the suggested framework, in which SNA and machine learning are combined, we have attempted to explore the factors that may have been integral to learner performance based on VLE behaviour.

Research Methods

The main research processes that were undertaken in this study are summarised in Figure 1. Data exploration and visualisation were conducted to obtain information about the learners, the courses they enrolled in, and the virtual learning resources they accessed for each course they were enrolled in. Social network graphs were constructed depicting the online behaviour of each learner before computing the centrality values chosen for each node in the graph. Data preprocessing was then conducted to assign the binary labels *graduated* and *did not graduate* to each learner based on their final grade (Table 1). Finally, we trained and tested binary classifiers with the data we had prepared using supervised and ensemble learning algorithms to predict whether a learner was able to successfully clear a course. The machine learning technique was used not only to compare the performance across all classifiers but also to gain more insights via the analysis of each classifier's performance in the prediction task to find out the common behavioural aspects of learners that adversely affected prediction performance across all classifiers.

Figure 1

Main Research Processes

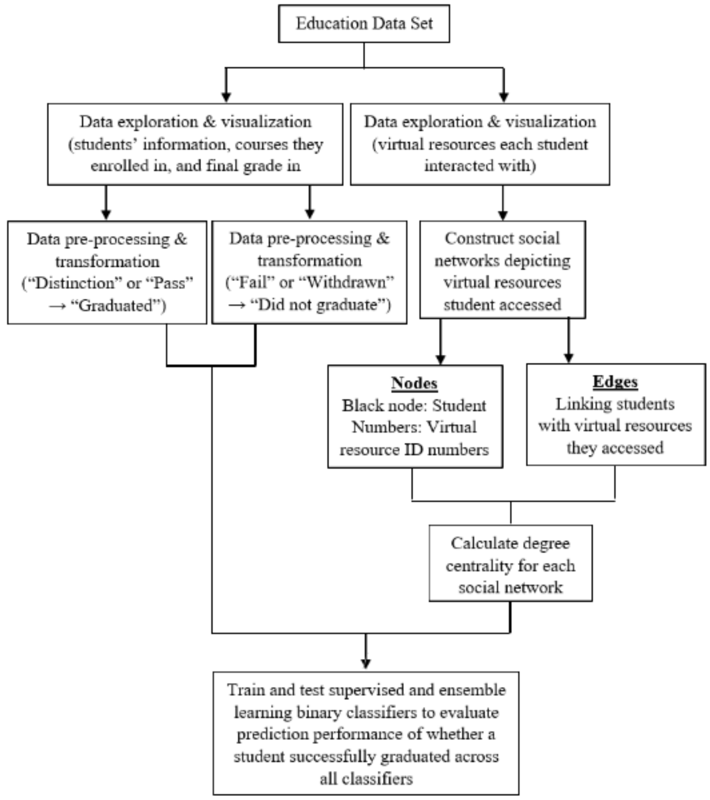


Table 1

Assignment of Class Labels to the Final Result

Final result	Class label
Distinction, pass	Graduated
Withdrawn, fail	Did not graduate

Description of Data Set

The publicly available anonymised OULAD was used in this study; its structure is illustrated in Figure 2. It primarily contains information about the learners from seven different courses, their activity within the VLE, and the assessments they completed for each course in 2013 and 2014. The data also contain their achieved results for the course. There are two semesters or presentations for each year, which commenced in February and October, and are labelled B and J, respectively. Some courses offered in B may not be offered in J, and vice versa. Details about the data contained in each of the seven records found in the data set are displayed in Figure 3, and Figure 4 presents an overall summary of learner demographics and backgrounds.

Figure 2

Structure of Data Set

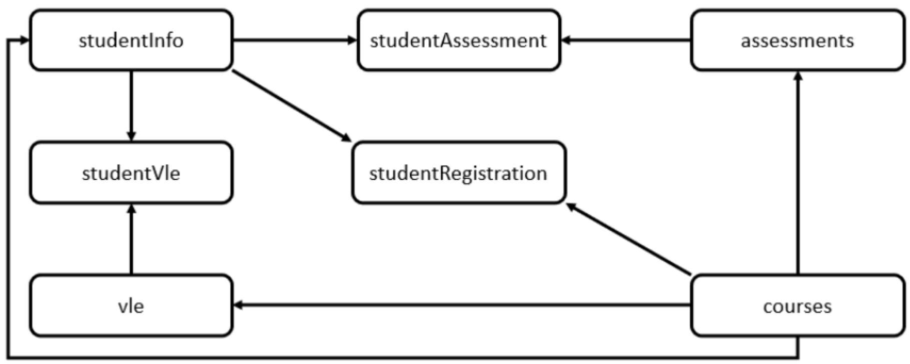


Figure 3

Information in Data Records

studentInfo	studentVle	vle	student Assessment
• code_module • code_presentation • id_student • gender • region • highest_education • imd_band • age_band • num_of_prev_attempts • studied_credits • disability • final_result	• code_module • code_presentation • id_student • id_site • date • sum_click	• id_site • code_module • code_presentation • activity_type • week_from • week_to	• id_assessment • id_student • date_submitted • is_banked • score

assessments	student Registration	courses
• code_module • code_presentation • id_assessment • assesment_type • date • weight	• code_module • code_presentation • id_student • date_registration • date_unregistration	• code_module • code_presentation • length

Figure 4

Summary of Learner Demographics and Backgrounds

Gender	2013B	2013J	2014B	2014J
Male	2,295	4,645	4,436	6,499
Female	2,389	4,200	3,368	4,761

Age band	2013B	2013J	2014B	2014J
0-35	3,262	6,216	5,581	7,885
35-55	1,402	2,566	2,187	3,278
55 and older	20	63	36	97

Highest education	2013B	2013J	2014B	2014J
A level or equivalent	2,011	3,786	3,331	4,917
HE qualification	632	1,195	1,123	1,780
Lower than A level	1,957	3,715	3,153	4,333
No formal qualifications	52	85	97	113
Postgraduate qualification	32	64	100	117

Disability	2013B	2013J	2014B	2014J
No	4,221	7,996	7,029	10,183
Yes	463	849	775	1,077

IMD band	2013B	2013J	2014B	2014J
0-10%	506	883	818	1,104
10-20%	505	972	841	1,198
20-30%	562	931	909	1,252
30-40%	517	967	855	1,200
40-50%	469	893	747	1,147
50-60%	451	862	708	1,103
60-70%	399	777	686	1,043
70-80%	408	805	662	1,004
80-90%	348	757	697	960
90-100%	342	731	609	854

Region	2013B	2013J	2014B	2014J
East Anglian region	493	972	813	1,062
East Midlands region	306	637	605	817
Ireland	184	347	211	442
London region	521	803	812	1,080
North region	273	464	448	638
Northwestern region	402	808	738	958
Scotland	380	904	781	1,381
Southeast region	288	579	495	749
South region	437	847	772	1,036
Southwest region	390	638	569	839
Wales	312	576	445	753
West Midlands region	395	709	623	855
Yorkshire region	303	561	492	650

Note. HE = higher education; IMD = indices of multiple deprivation.

Besides identification code, domain, and course length, no further information regarding the structure or contents of the course was provided in the data set. Furthermore, as our study is based on how a learner behaved within a VLE, our analysis of the data set showed that the only behavioural features recorded were the virtual resources a learner accessed and the number of clicks made within that resource on a given date. As the latter was not indicative of how the learner was interacting with the resource, and no data were given about the content of the resource, we did not include the number of clicks as a behavioural feature to avoid interpreting it incorrectly.

Each course in each presentation will have a separate VLE, in which a variety of virtual resources will be made available to supplement learners' learning and also to assess their understanding of the course material. These resources can be in the form of Hyper Text Markup Language (HTML) pages, Portable Document Format (PDF) files, or some other form of media. A basic summary of the courses, the learners in each course, and virtual resources in the VLE for each course across all presentations are presented in Table 2. The courses were not offered if they had zero learners and resources in a particular presentation.

Table 2

Number of Learners and Virtual Resources per Course (in Each Semester or Presentation)

Course	Domain	2013B		2013J		2014B		2014J	
		Learners	Virtual resources	Learners	Virtual resources	Learners	Virtual resources	Learners	Virtual resources
AAA	Social sciences	0	0	378	209	0	0	357	197
BBB	Social sciences	1,537	315	1,870	320	1,294	311	1,921	206
CCC	STEM	0	0	0	0	1,681	180	2,302	220
DDD	STEM	1,214	408	1,768	456	1,116	447	1,647	361
EEE	STEM	0	0	964	107	624	104	1,097	110
FFF	STEM	1,510	500	2,098	526	1,363	475	2,121	449
GGG	Social sciences	0	0	895	137	773	124	698	106

Note. STEM = science, technology, engineering, and mathematics.

Data Preprocessing and Visualisation

Data preprocessing was carried out to ensure the data set had binary labels to learn from and predict before we trained a binary classifier. This was conducted by labelling learners who achieved a distinction or pass the result as *graduated* and those who got a final result of fail or withdrawn as *did not graduate*. The virtual resource node's centrality values were then computed and used to predict learners who did and did not graduate.

Figure 5 illustrates the percentage of graduated and nongraduated learners for four different presentations: 2013B, 2013J, 2014B, and 2014J. More learners were able to graduate in 2013B compared with 2014B, and more learners were able to graduate in 2013J compared to 2014J.

Figure 5

Graduating Versus Nongraduating Learners per Presentation

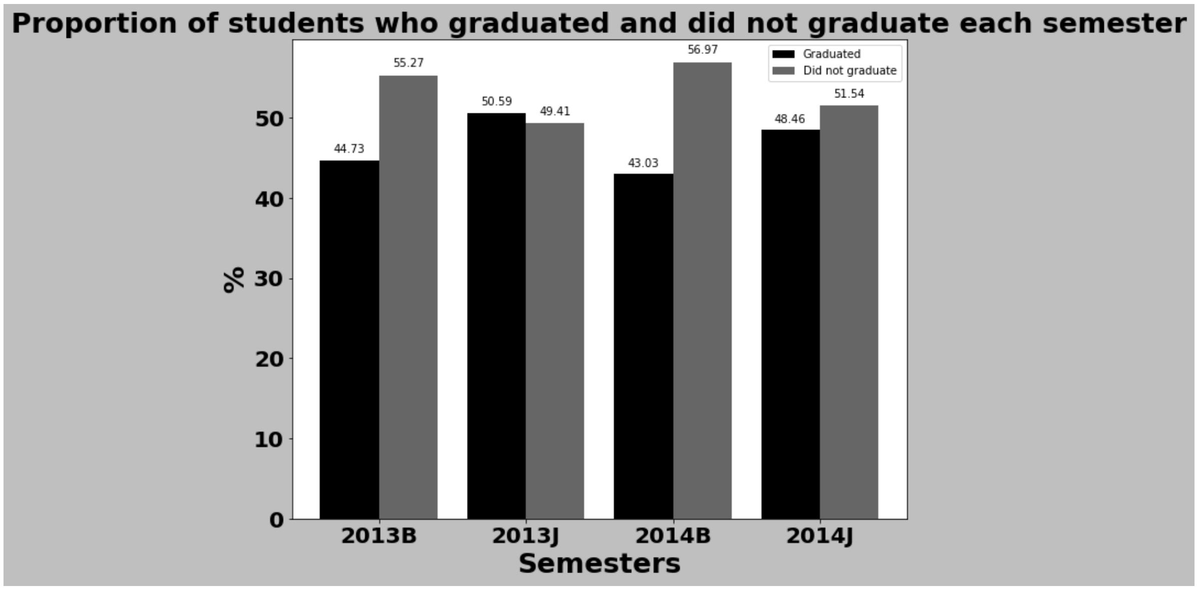
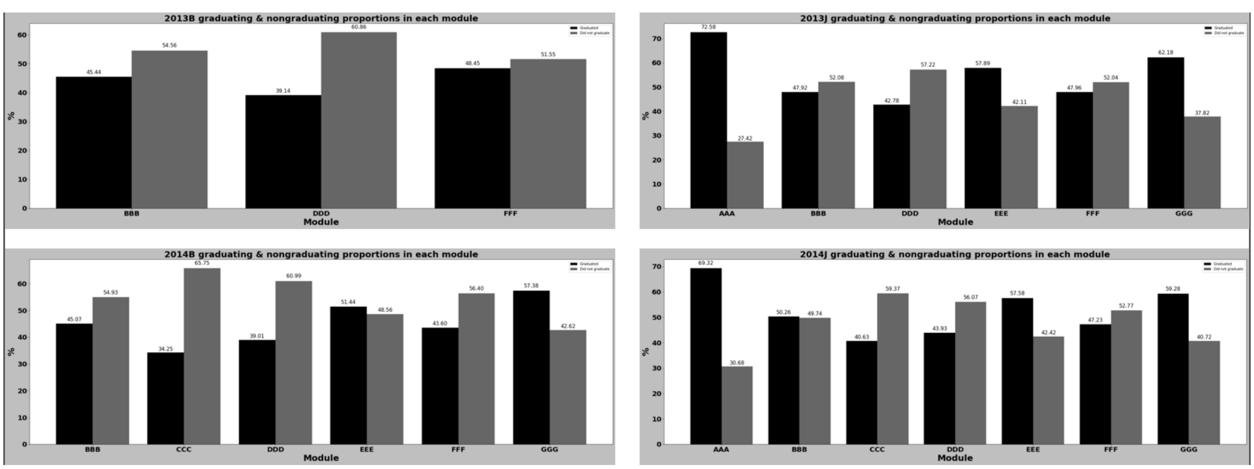


Figure 6 shows a detailed breakdown of the proportion of graduating and nongraduating learners for each course in each semester. Courses BBB, DDD, and FFF had higher numbers of nongraduating learners in both presentations in 2013. The inclusion of the course CCC seemed to cause a spike in the overall number of nongraduating learners; it had the highest proportion of nongraduating learners compared with the other courses in 2014. In both 2013 and 2014, courses AAA, EEE, and GGG had more learners graduating.

Figure 6

Graduating Versus Nongraduating Learners for Each Course in Each Presentation



Data Analysis and Results

In this study, SNA was used to analyse learners' online behaviour via their interactions with virtual resources in the course they were enrolled in. Due to course CCC's influence on the nongraduating population in both semesters in 2014, and because course GGG had more learners who graduated in these semesters, we chose to focus on predicting the performance of learners enrolled in these courses (CCC and GGG) in 2014 observe whether they would differ in terms of prediction performance.

Each learner has an undirected social network graph that depicts the unique resources a learner accessed for the entirety of a course. A black node is used for the learner while resource identification numbers are used to indicate which virtual resources the learner accessed. The edges in the network represent the learner accessing the virtual resource at least once in the course and are weighted based on the number of times the learner accessed that particular virtual resource for the duration of the course.

The social networks were constructed in this manner as we opted to visualise the learners and virtual resources as entities of the same type, among which there is an exchange of information from both sides. Nevertheless, we could not draw any edges between any two resources in the social networks we had constructed, and we also could not construct a social network dedicated to the resources as no information was provided on whether the resources interacted with each other. Furthermore, we could not construct social networks to visualise and observe these as no records were provided in the data set about interactions between learners or information related to forum discussions.

A summary of the learner population, the number of virtual resources in the course's VLE for the semester, and data related to the social networks for each course we focused on are presented in Table 3.

Table 3

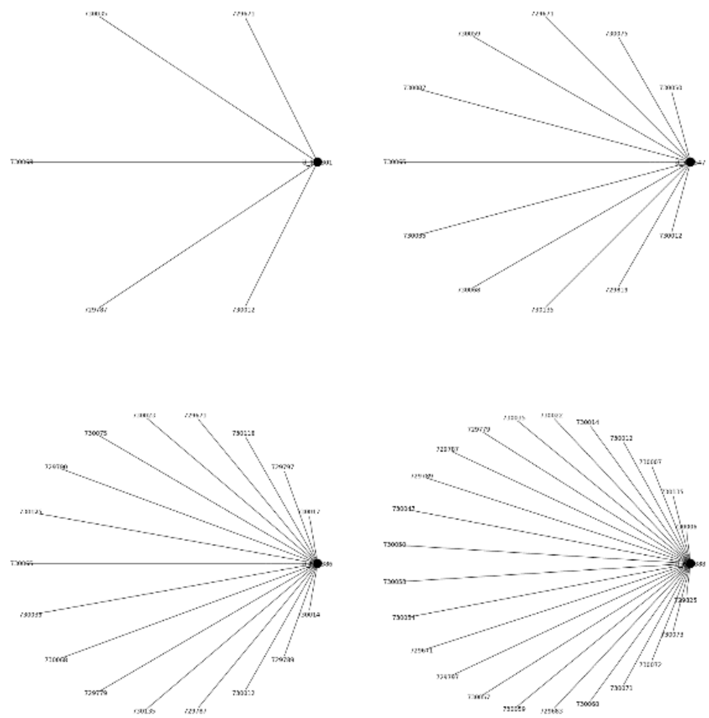
Summary of Data for Social Networks of Each Learner in Courses CCC and GGG in 2014

Variable	CCC_2014B	CCC_2014J	GGG_2014B	GGG_2014J
Learners	1,681	2,302	773	698
Virtual resources	180	220	124	106
Social networks constructed	1,681	2,302	773	698
Min. number of nodes	1	1	1	1
Max. number of nodes	181	221	125	107
Min. number of edges	0	0	0	0
Max. number of edges	180	220	124	106

After we constructed the social networks for each learner in courses CCC and GGG, of which some examples are shown in Figure 7, we computed the degree centralities for each network. Golbeck (2013) defines degree centrality as the number of edges a node has or the number of nodes a node is linked to. Degree centrality was employed based on the aim of our study, which was to analyse how a learner's interaction with virtual resources in a VLE affects their performance.

Figure 7

Samples of Constructed Social Networks Depicting Resources a Learner Interacted With



Based on the computed degree centralities of each network, we observed that all learners had a constant centrality value as they only have edges linking their nodes to the course nodes. Depending on the number of nodes in the social network graph, all virtual resources a learner access will approximately have the same centrality value, as there is only one edge linking each virtual resource node with a learner and no edges between any virtual resource nodes. The overall distribution of the virtual resource degree centrality values for the entire course cohort is shown in Figure 8, and the distributions of the virtual resource degree centrality values for the learners who graduated and did not graduate for courses CCC and GGG are displayed in Figures 9 and 10, respectively.

Figure 8

Distribution of Degree Centrality for Entire Learner Cohort in Courses CCC and GGG in 2014

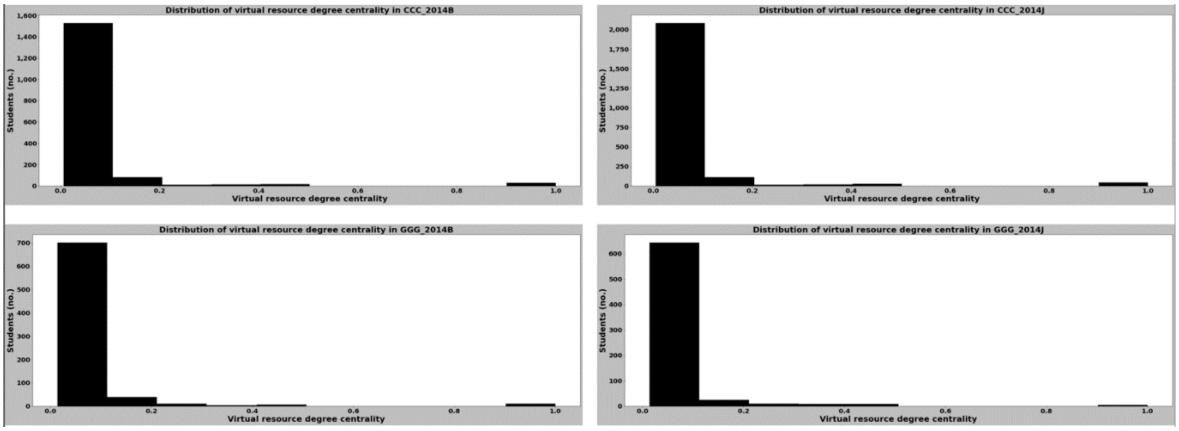


Figure 9

Distribution of Degree Centrality for Graduating and Nongraduating Cohorts in Course CCC in 2014

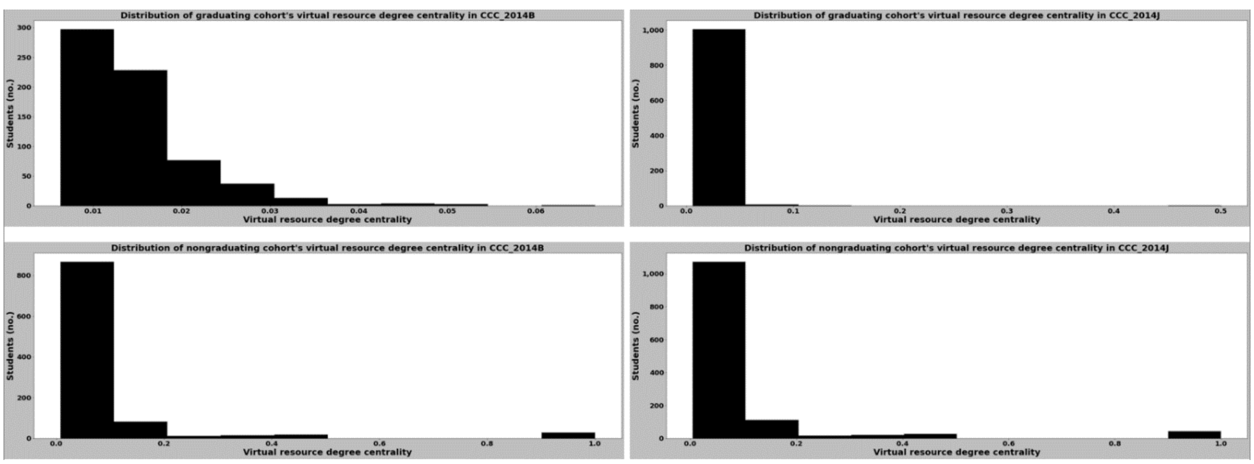
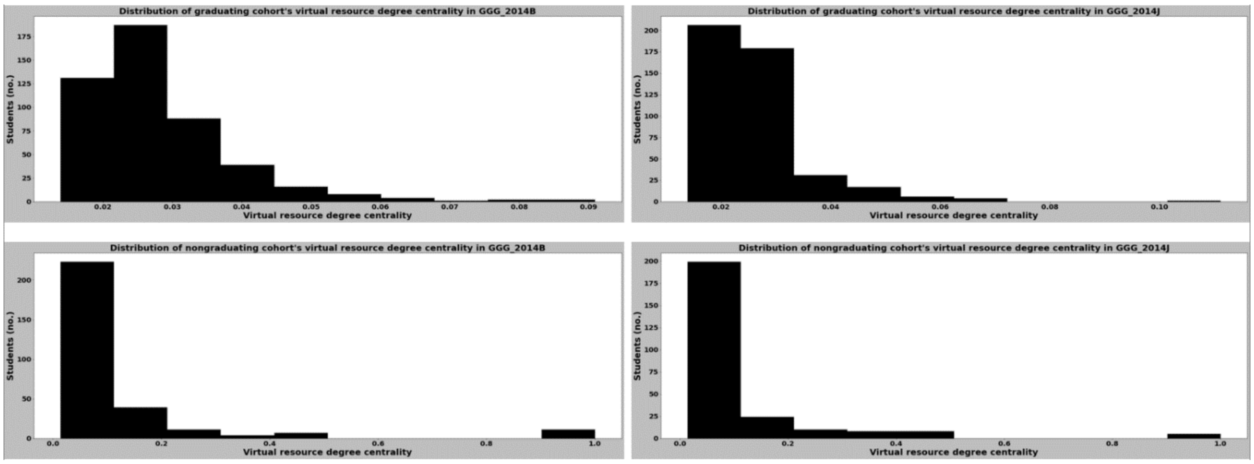


Figure 10

Distribution of Degree Centrality for Graduating and Nongraduating Cohorts in Course GGG in 2014



The distributions in Figures 9 and 10 indicate that virtual resource access does not seem to be a key contributor to the differences between the graduating proportions of students in courses CCC and GGG. Furthermore, Figure 8 shows that the distribution of the virtual resource degree centrality values for both courses in both semesters are similar; with the mean degree centrality values ranging between 0.058 and 0.065.

By comparing the range of values in each distribution shown in Figures 9 and 10, we found that the virtual resource degree centrality values for learners who graduated had a narrower range compared with those of learners who did not graduate, regardless of the course they were enrolled in. This could be due to differences in the total virtual resources accessed by the learners in either group for the duration of the courses, which can be observed in the differences between the distributions of the total number of virtual resources accessed (Figures 11, 12).

Figure 11

Distribution of the Total Number of Virtual Resources Accessed for Graduating and Nongraduating Cohorts in Course CCC in 2014

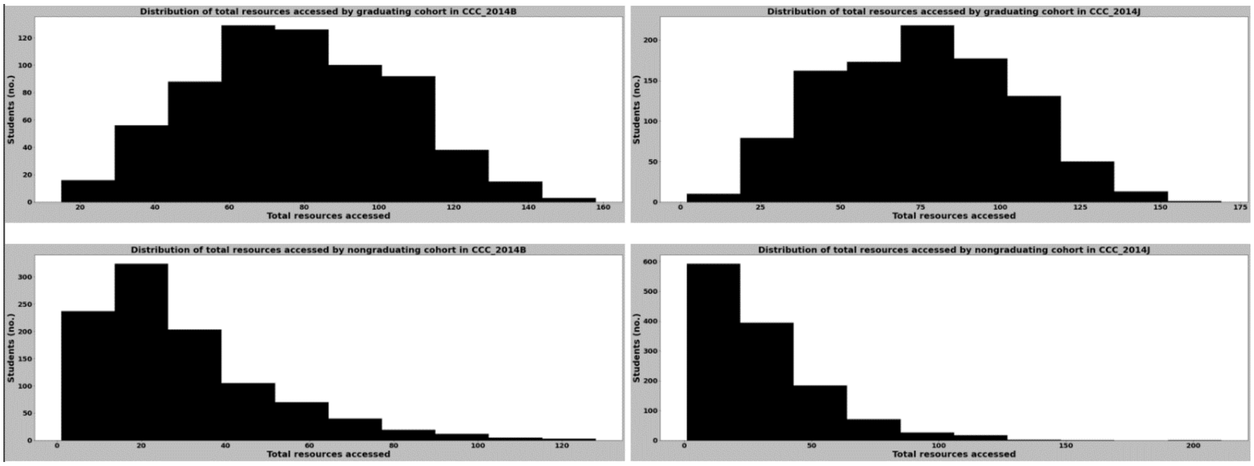
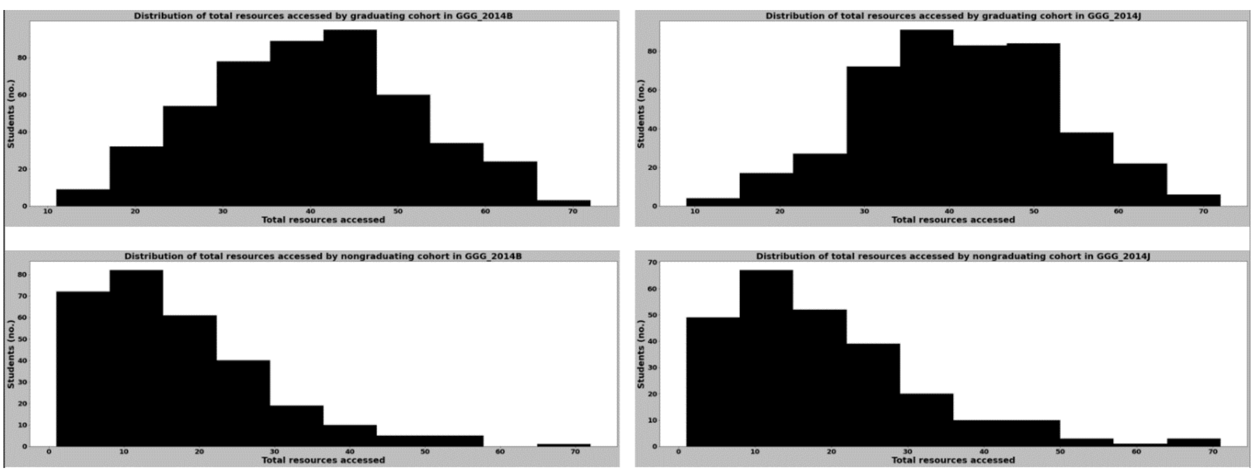


Figure 12

Distribution of the Total Number of Virtual Resources Accessed for Graduating and Nongraduating Cohorts in Course GGG in 2014



As the main focus of this study was the binary classification of learners who did or did not graduate, we trained a variety of binary classifiers that employed either supervised learning or ensemble learning in the scikit-learn Python library. For each course in each presentation, training and test data sets consisting of the degree centrality values along with the labels for the learners' final performance were used to train and test the binary classifiers.

Using Degree Centrality Values to Predict Learner Performance

Table 4 summarises the accuracy obtained with the training and test data sets for each course. The binary classifiers we had trained performed well with the virtual resource degree centrality values as features; the accuracy we obtained with them was primarily at least 80% for both the training and test sets. No disparity existed in accuracy between the supervised learning classifiers and the ensemble learning classifiers. However, the accuracy for the CCC_2014J test set was the poorest (around 70%–72%) for most of the ensemble learning methods.

Table 4

Binary Classifier Accuracy (%)

Classifiers	CCC_2014B		CCC_2014J		GGG_2014B		GGG_2014J	
	Train	Test	Train	Test	Train	Test	Train	Test
Logistic regression	83.41	84.87	80.07	80.91	84.47	81.94	84.95	82.86
K-nearest neighbours	84.52	77.74	80.23	80.04	83.82	83.87	86.56	80.00
Support vector machines	83.41	85.46	80.45	80.69	85.60	83.87	86.02	82.86
Decision tree	84.75	80.12	82.07	71.58	85.92	78.71	87.28	81.43
Bagging classifier	83.93	80.12	81.64	70.72	85.60	84.52	86.92	81.43
AdaBoost	84.75	81.01	81.10	70.50	85.92	84.52	87.28	82.14
Random forest	84.75	81.60	81.91	71.37	85.92	85.81	87.28	81.43
Voting classifier	84.67	81.01	81.75	81.34	85.60	83.23	86.92	81.43

To further analyse which label predictions had impacted the accuracy of the classifiers, we analysed the precision, recall, and F1-score of each classifier for each label in courses CCC and GGG, which are displayed in Tables 5 and 6, respectively. These performance metrics further support the fact that the degree centrality features perform well in predicting a learner's performance. Nevertheless, most of the classifiers reflected poor recall for learners who graduated from course CCC (63%–75%) and learners who did not graduate from course GGG (60%–71%).

Table 5

Classification Report for Predicting Performance in Course CCC with Virtual Resource Degree Centralities

Classifier	Label	CCC_2014B			CCC_2014J		
		Precision (%)	Recall (%)	F1-score (%)	Precision (%)	Recall (%)	F1-score (%)
Logistic regression	Did not graduate	89.08	82.89	85.87	93.94	70.99	80.87
	Graduated	80.37	87.33	83.71	71.10	93.97	80.95
K-nearest neighbours	Did not graduate	77.45	84.49	80.82	89.35	73.66	80.75
	Graduated	78.20	69.33	73.50	71.84	88.44	79.28
Support vector machines	Did not graduate	90.12	82.89	86.35	93.03	71.37	80.78
	Graduated	80.61	88.67	84.44	71.15	92.96	80.61
Decision tree	Did not graduate	78.04	89.30	83.29	73.82	77.48	75.61
	Graduated	83.74	68.67	75.46	68.28	63.82	65.97
Bagging classifier	Did not graduate	80.61	84.49	82.51	73.43	75.95	74.67
	Graduated	79.43	74.67	76.98	66.84	63.82	65.30
AdaBoost	Did not graduate	79.15	89.30	83.92	73.86	74.43	74.14
	Graduated	84.13	70.67	76.81	65.99	65.33	65.66

Classifier	Label	CCC_2014B			CCC_2014J		
		Precision (%)	Recall (%)	F1-score (%)	Precision (%)	Recall (%)	F1-score (%)
Random forest	Did not graduate	80.19	88.77	84.26	74.07	76.34	75.19
	Graduated	83.85	72.67	77.86	67.54	64.82	66.15
Voting classifier	Did not graduate	80.60	86.63	83.51	91.90	73.66	81.78
	Graduated	81.62	74.00	77.62	72.51	91.46	80.89

Table 6

Classification Report for Predicting Performance in Course GGG with Virtual Resource Degree Centralities

Classifier	Label	GGG_2014B			GGG_2014J		
		Precision (%)	Recall (%)	F1-score (%)	Precision (%)	Recall (%)	F1-score (%)
Logistic regression	Did not graduate	100.00	60.56	75.44	97.06	58.93	73.33
	Graduated	75.00	100.00	85.71	78.30	98.81	87.37
K-nearest neighbours	Did not graduate	97.92	66.20	78.99	85.00	60.71	70.83
	Graduated	77.57	98.81	86.91	78.00	92.86	84.78
Support vector machines	Did not graduate	97.92	66.20	78.99	94.44	60.71	73.91
	Graduated	77.57	98.81	86.91	78.85	97.62	87.23
Decision tree	Did not graduate	75.68	78.87	77.24	82.61	67.86	74.51
	Graduated	81.48	78.57	80.00	80.85	90.48	85.39
Bagging classifier	Did not graduate	92.73	71.83	80.95	85.71	64.29	73.47
	Graduated	80.00	95.24	86.96	79.59	92.86	85.71
AdaBoost	Did not graduate	92.73	71.83	80.95	86.05	66.07	74.75
	Graduated	80.00	95.24	86.96	80.41	92.86	86.19
Random forest	Did not graduate	92.98	74.65	82.81	85.71	64.29	73.47
	Graduated	81.63	95.24	87.91	79.59	92.86	85.71
Voting classifier	Did not graduate	97.87	64.79	77.97	85.71	64.29	73.47
	Graduated	76.8%	98.81	86.46	79.59	92.86	85.71

To identify what contributed to poor recall for the groups in courses CCC and GGG, we compared the distribution of the virtual resource degree centrality values of the wrongly classified learners in each group and also the distributions of the total number of virtual resources these learners accessed (Figures 13–16). By comparing these distributions together with those in Figures 9–12, we found that most of the learners who were misclassified had virtual resource degree centrality values that were clustered around a particular range for both the graduating and nongraduating cohorts. Furthermore, the findings revealed that some learners who were wrongly classified had virtual resource degree centrality values that rarely occurred. All clusters and rare values of centrality values we observed are shown in Table 7.

Figure 13

Distribution of Virtual Resource Degree Centralities for Wrongly Classified Learners in Course CCC in 2014

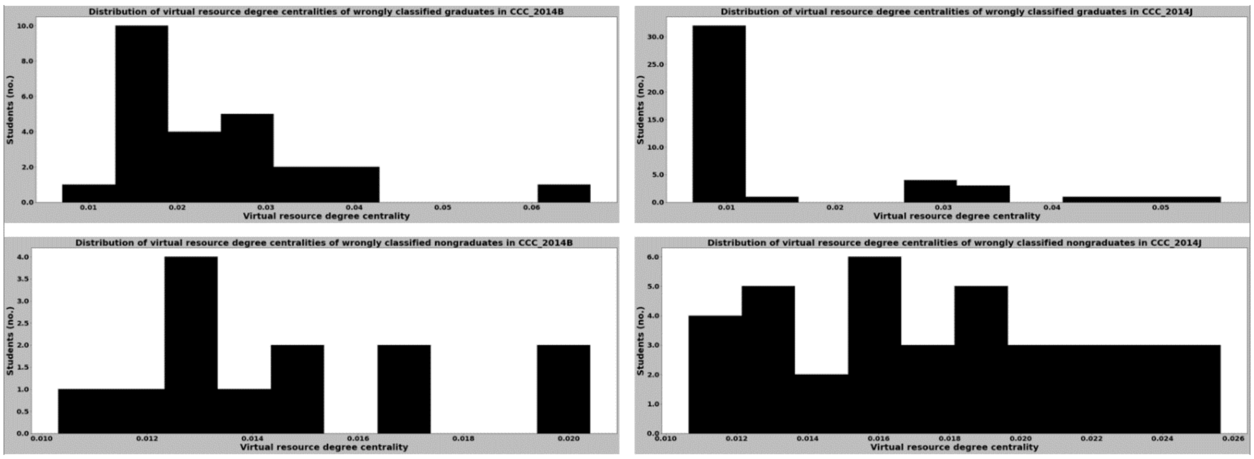


Figure 14

Distribution of Virtual Resource Degree Centralities for Wrongly Classified Learners in Course GGG in 2014

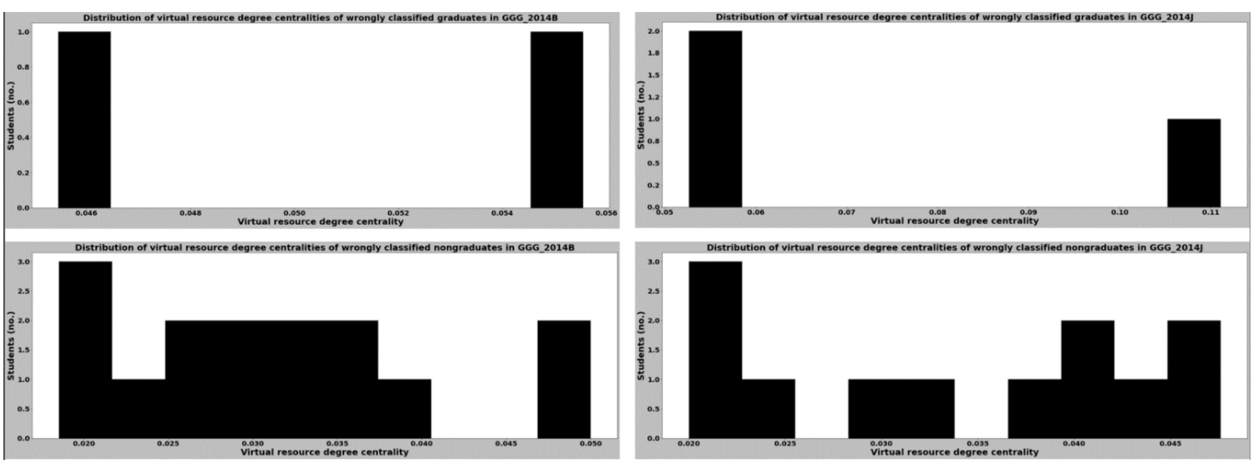


Figure 15

Distribution of the Total Number of Virtual Resources Accessed for Wrongly Classified Learners in Course CCC in 2014

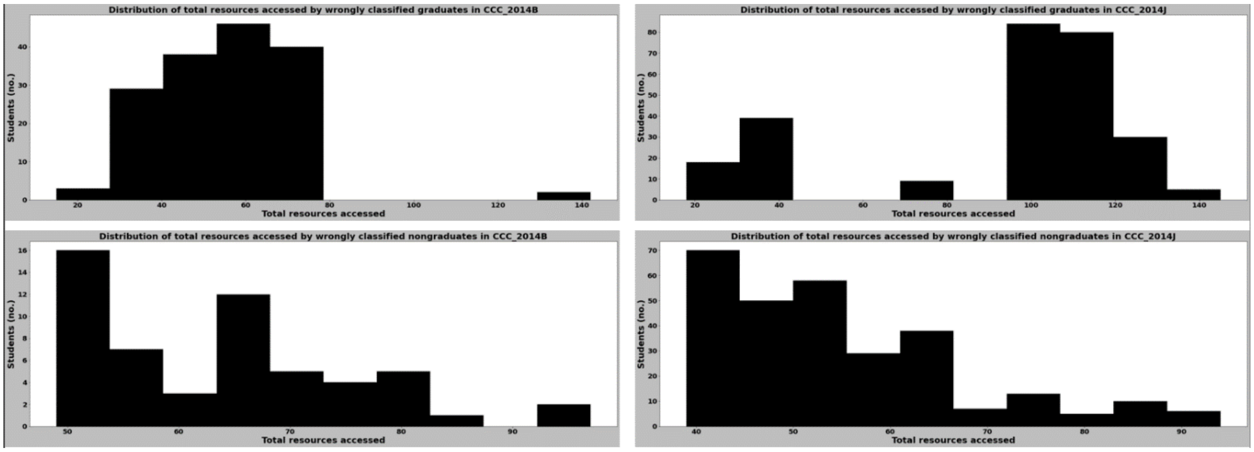


Figure 16

Distribution of the Total Number of Virtual Resources Accessed for Wrongly Classified Learners in Course GGG in 2014

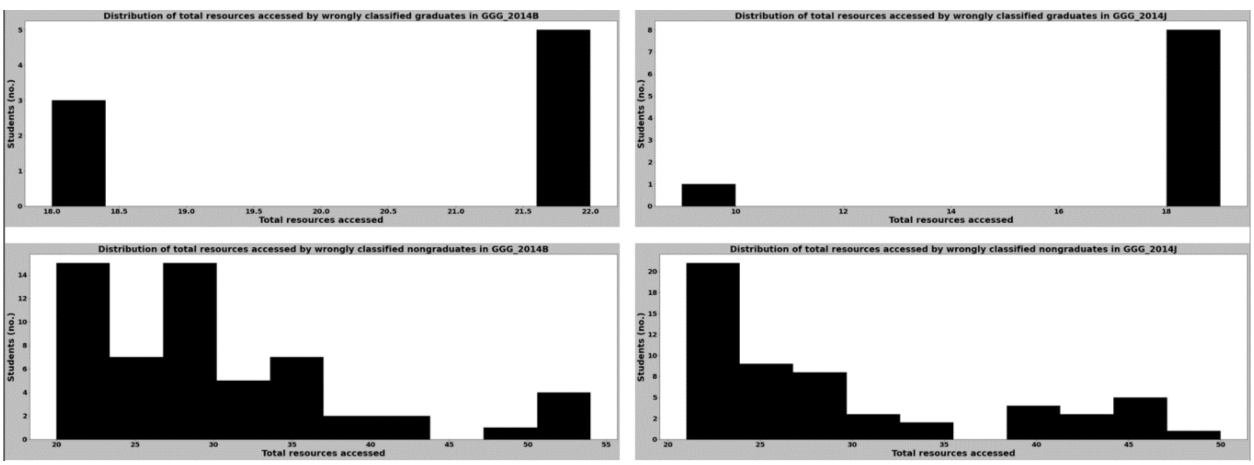


Table 7

Clusters and Rare Values Observed in Wrongly Classified Data

Variable	CCC_2014B		CCC_2014J		GGG_2014B		GGG_2014J	
	Clusters	Rare values	Clusters	Rare values	Clusters	Rare values	Clusters	Rare values
Virtual resource degree centrality	0.01–0.040	0.007, 0.067	0.01–0.026	< 0.008, > 0.04	0.018–0.05	0.056	0.02–0.05	0.05, 0.1
Total number of virtual resources accessed	24–100	15, 142	30–100	< 30, > 125	20–55	18	20–50	9, 18, 19

Discussion

The chosen binary classifiers on the virtual resource degree centrality values are trained and tested, and we obtained an accuracy of 80%–85% on the test set of both courses across most of the binary classifiers. The overall level of performance we observed appears to be promising and encouraging.

Our analysis of the classifiers' performance shows that the accuracy for the test set of CCC_2014 was poorest for most of the ensemble learning methods compared with the other course cohorts, and when the metrics for each classifier were compared and analysed, most of the binary classifiers performed rather poorly in recall for learners who graduated from course CCC and learners who did not graduate from course GGG. Our initial assessment was that the classifiers would have been unable to classify some learners in the graduating and nongraduating cohorts because of inconsistencies in their virtual resource degree centralities.

We derived insight from analysing the distribution of the virtual resource degree centralities together with the distribution of the total resources accessed by learners who were wrongly classified. The binary classifiers we employed in this study were not able to separate clusters due to common behaviours among the graduating and nongraduating cohorts into the different groups of learners they consisted of during the training of each classifier, and there were very few instances of the rare centrality values to be trained upon. Therefore, the binary classifiers, regardless of whether they were based on supervised or ensemble learning, faced difficulties in classifying learners who had such virtual resource degree centrality values.

A limitation of our study is that the machine learning classifiers were unable to correctly predict whether some learners would or would not graduate due to anomalies in their online behaviour. If more data were available related to how a learner had interacted with a virtual resource and/or the amount of time spent with/on it, as well as more data indicative of the actual content in a resource, we would have been able to incorporate them into the construction of the social networks for a more accurate depiction of a learner's online behaviour, and the classifiers could have distinguished and predicted learners who graduated from those who did not. Such data could also provide more insights into factors affecting learners.

Conclusion

In this study, we attempted to predict learners' academic performance based on their interactions with the resources provided in a course's virtual learning environment. SNA was performed to obtain the degree centrality of the virtual resources that learners interacted with. Using the virtual resource degree centrality value for each learner, supervised learning and ensemble learning binary classifiers were leveraged to predict whether a learner would graduate from a course.

The overall accuracy we obtained with the chosen binary classifiers on degree centrality values is promising. The performance metrics for all classifiers revealed that the virtual resource degree centrality value is a viable feature to predict learner performance, which further implies that learners' interactions with virtual resources have a significant effect on their performance. This was true for both the courses we focused on in this study despite the differences in the proportions of graduating and nongraduating cohorts.

Instructors and course facilitators may make use of our framework to monitor a learner's learning based on their interactions with virtual resources at any point in the course, especially the SNA component, to help them visualise and understand a learner's online behaviour. The social network depicting the online behaviour of each learner is straightforward to understand, and instructors will be able to detect learners who are falling behind based on the size of their social network compared with other learners. This, coupled with data related to the learner's session activity with each virtual resource they interacted with, would greatly assist in promptly providing early intervention and support to learners who are performing below average. With more comprehensive data about resources and how learners interacted with them, the perspective of social networks may be shifted to better understand how learners are interacting with each resource and whether a learner is facing any difficulty with a resource based on their behaviour with it (e.g., less or more time spent on a resource compared with other learners, unusual interaction with a resource).

In addition, by leveraging machine learning to predict learner performance, instructors and course facilitators will be able to analyse and gain in-depth insights about common learner behavioural traits or anomalous behaviour in the past and how these affected learners' performance. At-risk learners could be identified early, and in-time intervention provided. Eventually, the success of a course could be improved, and subsequently, dropout risk could be reduced.

Our study primarily focused on implementing a framework for visualising the online behaviour of learners in courses that heavily rely on virtual environments to disseminate knowledge and assess the understanding of each learner. We also demonstrated that data derived from analysing learners' online behaviour can be used to predict whether learners can successfully complete a course. With the performance scores we obtained with our framework, along with the insights we gained into the gaps in our predictive models, we have gained a good idea of what works and what can be done to improve the predictive models.

In the future, we seek to improve the prediction models' performance by using a range of final result values instead of categorical labels to overcome the clustering in the virtual resource node centrality values among graduating and nongraduating learners. Further work may also include examining which virtual resources contribute most to a learner's performance. Finally, we aim to apply the proposed framework to other education-related data sets with more data on how students interacted with each other to better understand how this interaction affects their learning.

References

Agudo-Peregrina, Á. F., Hernández-García, Á., & Iglesias-Pradas, S. (2012, October). Predicting academic performance with learning analytics in virtual learning environments: A comparative study of three interaction classifications. In F. José García, L. Vicent, M. Ribó, A. Climent, J. L. Sierra, & A. Sarasa (Eds.), *2012 International Symposium on Computers in Education (SIIE)* (pp. 1–6). Institute of Electrical and Electronics Engineers. https://ieeexplore.ieee.org/document/6403184

Al-Azawei, A., & Al-Masoudy, M. (2020). Predicting learners' performance in virtual learning environment (VLE) based on demographic, behavioral and engagement antecedents. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(9), 60–75. https://doi.org/10.3991/ijet.v15i09.12691

Albreiki, B., Zaki, N., & Alashwal, H. (2021). A systematic literature review of student' performance prediction using machine learning techniques. *Education Sciences*, *11*(9), 552. https://doi.org/10.3390/educsci11090552

Chung, K. S. K., & Paredes, W. C. (2015). Towards a social networks model for online learning & performance. *Educational Technology & Society*, *18*(3), 240–253. http://www.jstor.org/stable/jeductechsoci.18.3.240

de Barba, P. G., Kennedy, G. E., & Ainley, M. D. (2016). The role of students' motivation and participation in predicting performance in a MOOC. *Journal of Computer Assisted Learning*, *32*(3), 218–231. https://doi.org/10.1111/jcal.12130

Dragulescu, B., Bucos, M., & Vasiu, R. (2015). Social network analysis on educational data set in RDF format. *Journal of Computing and Information Technology*, *23*(3), 269–281. https://doi.org/10.2498/cit.1002645

Golbeck, J. (2013). Network structure and measures. *Analyzing the social Web* (pp. 25–44). Morgan Kaufmann. https://doi.org/10.1016/C2012-0-00171-8

Grunspan, D. Z., Wiggins, B. L., & Goodreau, S. M. (2014). Understanding classrooms through social network analysis: A primer for social network analysis in education research. *CBE—Life Sciences Education*, *13*(2), 167–178. https://doi.org/10.1187/cbe.13-08-0162

Khor, E.T. & Looi, C.K. (2019) A learning analytics approach to model and predict learners' success in digital learning. In Y. W. Chew, K. M. Chan, and A. Alphonso (Eds.), *Personalised Learning. Diverse Goals. One Heart. ASCILITE 2019 Singapore* (pp. 476-480). https://repository.nie.edu.sg/bitstream/10497/22077/1/ASCILITE-2019-476.pdf

Koza, J. R., Bennett, F. H., Andre, D., & Keane, M. A. (1996). Automated design of both the topology and sizing of analog electrical circuits using genetic programming. In J. S. Gero & F. Sudweeks (Eds.), *Artificial Intelligence in Design '96* (pp. 151–170). Springer, Dordrecht. https://doi.org/10.1007/978-94-009-0279-4_9

Kuzilek, J., Hlosta, M., & Zdrahal, Z. (2017). Open University learning analytics dataset. *Scientific Data*, *4*(1), Article 170171. https://doi.org/10.1038/sdata.2017.171

Mastoory, Y., Harandi, S. R., & Abdolvand, N. (2016). The effects of communication networks on students' academic performance: The synthetic approach of social network analysis and data mining for education. *International Journal on Integrating Technology in Education*, *5*(4), 23–34. https://doi.org/10.5121/ijite.2016.5403

Mitchell, T. M. (1997). *Machine learning*. McGraw-Hill.

Mariame, O., Khouljian, S. & Kerbeb, M.L. (2021). Feature engineering, mining for predicting student success based on interaction with the virtual learning environment using artificial neural network. *Annals of the Romanian Society for Cell Biology*, *25*(6), 12734–12746. https://www.annalsofrscb.ro/index.php/journal/article/view/8002/5907

Otte, E., & Rousseau, R. (2002). Social network analysis: A powerful strategy, also for the information sciences. *Journal of Information Science*, *28*(6), 441–453. https://doi.org/10.1177/016555150202800601

Rabbany, R., Takaffoli, M., & Zaiane, O. R. (2012). Social network analysis and mining to support the assessment of on-line student participation. *ACM SIGKDD Explorations Newsletter*, *13*(2), 20–29. https://doi.org/10.1145/2207243.2207247

Rakic, S., Pavlovic, M., Softic, S., Lalic, B., & Marjanovic, U. (2019, November). An evaluation of student performance at e-learning platform. In *2019 17th International Conference on Emerging eLearning Technologies and Applications (ICETA)* (pp. 681–686). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICETA48886.2019.9040066

Rakic, S., Softic, S., Vilkas, M., Lalic, B., & Marjanovic, U. (2018, November). Key indicators for student performance at the e-learning platform: An SNA approach. In *2018 16th International Conference on Emerging eLearning Technologies and Applications (ICETA)* (pp. 463–468). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICETA.2018.8572236

Rakic, S., Tasic, N., Marjanovic, U., Softic, S., Lüftenegger, E., & Turcin, I. (2020). Student performance on an e-learning platform: Mixed method approach. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(2), 187–203. https://doi.org/10.3991/ijet.v15i02.11646

Rivas, A., Gonzalez-Briones, A., Hernandez, G., Prieto, J., & Chamoso, P. (2021). Artificial neural network analysis of the academic performance of students in virtual learning environments. *Neurocomputing*, *423*, 713–720. https://doi.org/10.1016/j.neucom.2020.02.125

Saqr, M., Fors, U., & Nouri, J. (2018). Using social network analysis to understand online problem-based learning and predict performance. *PloS ONE*, *13*(9), Article e0203590. https://doi.org/10.1371/journal.pone.0203590

Sekeroglu, B., Dimililer, K., & Tuncal, K. (2019, March). Student performance prediction and classification using machine learning algorithms. In *ICEIT 2019: Proceedings of the 2019 8th International Conference on Educational and Information Technology* (pp. 7–11). Association for Computing Machinery. https://doi.org/10.1145/3318396.3318419

Waheed, H., Hassan, S. U., Aljohani, N. R., Hardman, J., Alelyani, S., & Nawaz, R. (2020). Predicting academic performance of students from VLE big data using deep learning models. *Computers in Human Behavior*, *104*, Article 106189. https://doi.org/10.1016/j.chb.2019.106189

Wolff, A., Zdrahal, Z., Nikolov, A., & Pantucek, M. (2013, April). Improving retention: Predicting at-risk students by analysing clicking behaviour in a virtual learning environment. In D. Suthers, K. Verbert, E. Duval, & X. Ochoa (Eds.), *LAK '13: Proceedings of the Third International Conference on Learning Analytics and Knowledge* (pp. 145–149). Association for Computing Machinery. https://doi.org/10.1145/2460296.2460324

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Open Distance and e-Learning: Ethiopian Doctoral Students' Satisfaction with Support Services

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Abstract

This study assessed students' level of satisfaction with the quality of student support services provided by an open distance e-learning (ODeL) university in Ethiopia. The target population was doctoral students who had been registered at the ODeL university for more than a year. To conduct a quantitative investigation, data were collected by means of a 34-item six-dimensional standardized questionnaire. Data analysis methods included linear as well as stepwise regressions. Using the gaps model as the theoretical framework, findings showed that the doctoral students were dissatisfied with four aspects of the student support services, namely supervision support, infrastructure, administrative support, and academic facilitation. In contrast, students were satisfied with the corporate image (reputation) of the ODeL university. For this ODeL university to play an effective role that coheres with the country's socio-economic development plan, more attention should be given to the provision of supervision support, as there was strong dissatisfaction with this. The university could also build on or leverage aspects of their corporate image, for which there was strong satisfaction. Doing so will help the university make ongoing contributions and strengthen its commitment to the field of higher education and human capacity development in Ethiopia.

Keywords: doctoral students, gaps model, ODeL, satisfaction, service quality, student support

Open Distance and e-Learning: Ethiopian Doctoral Students' Satisfaction with Support Services

The socio-economic developmental goals of countries around the world are realised through the continued growth of human resource capacity. The higher education sector has a decisive role to play, especially as its contribution to human capital development, which is expected to bring about positive and meaningful changes in countries' socio-economic conditions (Van Deuren et al., 2016). In its effort to achieve the United Nations' Sustainable Development Goals (UN SDGs), the government of Ethiopia emphasised human capital development as one of its key strategies. The government has been working towards ensuring the availability of requisite human resource and skills capacity at all levels of expertise. The Ethiopian National Science Policy and Strategy identifies human capacity development "as a major driving force for the progress and advancement of a nation" (Ministry of Science and Higher Education [MoSHE], 2020b, p. 18).

For Ethiopia to become "the African Beacon of Prosperity by 2030" (MoSHE, 2020a, p. 10), higher education will be on the frontier of development. In this regard, the Ethiopian Ministry of Science and Higher Education has been working aggressively towards producing 5,000 PhDs within five years (2021–2025). This plan called for universities to work collaboratively, sharing resources to support doctoral students. The facilities needed for PhD studies can be enriched through the development of partnerships, as well as networking with local and international academic and research institutions. Experts from industry, academia, and the diaspora should form part of the supporting structure. These plans were intended to meet the national reform objectives in which doctoral education has a role to play. In turn, doctoral graduates were expected to have a strong impact on the socio-economic development of Ethiopia by contributing towards an improved standard of living for all its citizens (MoSHE, 2020a).

With this developmental objective in mind, the 51 public universities in Ethiopia have been classified into three categories—research, applied science, and comprehensive universities. The research universities were meant to focus on scientific research by offering masters' and PhD programmes. To do so, these universities established research centres to collaborate among one another, and with international academic institutions. Staff members at these universities were expected to conduct research and publish in internationally recognized academic journals. This expectation differed from universities that prepared professionals to practise in the world of work (e.g., business and industry) and do research supported by their links to institutions and indusandtries. The comprehensive universities in turn were expected to teach undergraduates, and to conduct research as academic institutions, (Sisay, 2020; Wodwossen, 2020).

For the past decade and a half, Open, Distance, and e-Learning (ODeL) has been successfully supporting the Ethiopian higher education landscape as it is offered by international universities that operate in collaboration with public and private higher education institutions. This sector has arguably contributed positively towards the human capacity development of the country. However, the authors of this article, who are employed at one of these ODeL institutions operating in Ethiopia, were aware of grassroots rumblings from both students and lecturers that may cause reputational damage, if not addressed timeously. For example, the quality of service that the universities have provided to postgraduate students is of major concern and should not be taken for granted. This study focused on identifying Ethiopian students' levels of satisfaction and dissatisfaction in relation to the support services provided by one of the ODeL universities.

In an ODeL system, student support services play a pivotal role, providing students with the necessary academic and emotional support during their doctoral journey (Ngaaso & Abbam, 2016). While it is always beneficial to support research students through academic workshops and seminars, supervisors' support should be responsive to students' needs. For example, timely, constructive, and consistent feedback to students' submissions has been shown to keep the momentum and tempo of their work steady and increases student satisfaction (O'Shea et al., 2015; Paposa & Paposa, 2022).

Students' feelings of loneliness could be managed by offering guidelines, and motivating them to join electronic networks and groups with students of similar academic interest. When students worked in groups, their belongingness to the university was heightened, which may have increased their sense of satisfaction (Dzakiria, 2005). A lack of student support may have resulted in lower success rates and increased dropout rates (Sibai et al., 2021). Hence, student support services served as anchors, particularly in ODeL institutions (Southard & Mooney, 2015).

In addition to the quality of the academic and emotional support provided to students, the concept of satisfaction was integral to the research reported in this article. Satisfaction has been understood as a key aspect of service quality (Teeroovengadum et al., 2016). From a marketing perspective, satisfied customers were ambassadors to sell the services provided by the business (Dann, 2008). Similarly, in the higher education ODeL sector, students were cared for because they were regarded as customers of and ambassadors for their affiliated institution. Students have been perceived as customers of higher education because major services like library facilities, course materials, and supervision systems were prepared specifically for students. They pay fees that have sustained higher education institutions (Tsige, 2016; Farooq et al., 2019). It is therefore imperative that educational service providers continuously strive towards satisfying and retaining students throughout their journey from application for admission until graduation (Jain et al., 2010).

This study investigated whether support services offered to doctoral students by an ODeL university satisfied their expectations. We designed a quantitative methodology with a questionnaire for data collection. The results from the responses to the questionnaire have been presented in the findings section below.

The gaps model (Parasuraman, et al., 1985) was adopted as an analytical framework, because it was argued that students' complaints and apparent dissatisfaction resulted from the gap between students' expectations and their actual experiences.

Considering the need for doctoral throughput to achieve Ethiopia's developmental objectives, the higher education sector should be proactive in identifying potential obstacles that may derail the production of doctorates. To this end, this study

- investigated the level of satisfaction experienced by Ethiopian doctoral students registered at an ODeL institution,
- identified which dimensions contributed more to explaining satisfaction, and

- offered recommendations regarding the aspects institutions should capitalise on in their efforts to improve quality.

The rest of this article explores studies related to the research problem, the theoretical framework used, a brief description of the methodology, the findings, and discussion. The article ends with conclusions and recommendations.

Service Quality and Student Satisfaction

The relationship between service quality and satisfaction has been a concern in various service-providing industries, including (a) education, (b) health, (c) hospitality and tourism, and (d) the police service. The main purpose for discussing service quality and its relationship with satisfaction has been to identify the drawbacks of the service provider and find solutions to overcoming such challenges. This process of assuring quality has helped companies retain existing customers and attract new ones (Nyenya & Bukaliya, 2015).

Since this study focused on service quality and satisfaction with particular reference to doctoral students enrolled in an ODeL university, we reviewed literature from the field of education. Accordingly, the literature focused on students' satisfaction and/or dissatisfaction with the quality of services offered by the educational service providers in different countries.

Using the SERVQUAL model, Sibai et al. (2021) undertook a study on the relationship of service quality with satisfaction. They collected data from 189 medical college students in Saudi Arabia and analysed data by means of descriptive statistics and regression analysis. The authors found that the students were dissatisfied with three dimensions of SERVQUAL, namely responsiveness, empathy, and tangibles. Similarly, Wael (2015) used SERVQUAL to collect data from students of all faculties at Pavia University, located in Italy. The study found that students' satisfaction was low on all five dimensions (i.e., tangibles, reliability, responsiveness, assurance, and empathy) because the students' experiences were less than their expectations of service quality. On the other hand, Napitupulu et al. (2018) measured student satisfaction with service facilities by using a 14-item, 2-dimensional questionnaire. They found that expectations were higher than experiences, and concluded that the services on offer by the XYZ University were not yet satisfactory to the users. A similar finding (i.e., negative relationship between service quality and satisfaction) was recorded by Khalil et al. (2018) who identified the extent of student satisfaction with service quality dimensions. Their study population was private schools in Egypt where 900 students were selected to fill out a questionnaire on SERVQUAL with the concept of institutional image as an added dimension. Their findings showed that among the five dimensions of SERVQUAL, reliability and responsiveness had a negative relationship with satisfaction. Datt and Singh (2021) studied students, graduates, and dropouts who were exposed to the different e-services offered by a university in India. They sent an e-questionnaire to this purposely selected group and used descriptive statistics (percentages) to analyse the results. They found that the respondents were dissatisfied with the (a) mobile application that was employed by the university, (b) grievance-handling system, (c) inaccessibility of the e-learning portal, and (d) unavailability of video-recorded lectures.

As opposed to the above, positive relationships between service quality dimensions and satisfaction were recorded in many studies, including Kara et al. (2016) who identified service quality dimensions related to student satisfaction. A 70-item, 5-point Likert scale questionnaire was distributed to 1,062 undergraduate students at eight public universities in Kenya. The study found that service quality and student satisfaction were statistically significantly and moderately related in seven of the ten dimensions. Student satisfaction was positively related to six quality dimensions, namely (a) quality of teaching facilities, (b) availability of textbooks, (c) administrative service quality, (d) reliability of university examinations, (e) perceived learning gains, and (f) quality of students' welfare services.

Ngaaso and Abbam (2016) also showed positive relationships between student support service quality and satisfaction. Respondents were 564 distance learning students at the University of Education in Ghana who filled out a four-point Likert scale questionnaire. The following were found to be the most important contributors to students' satisfaction: (a) self-check questions and exercises at the end of each chapter, (b) readiness of help desk staff to give the necessary assistance, and (c) the knowledge and skills of professors and tutors. On the other hand, Khalil et al. (2018), found tangibles, empathy, and assurance were positively related with satisfaction. In addition, school image was found to have a positive relationship with satisfaction, and contributed the biggest share in explaining satisfaction.

Ntabathia (2013) also showed positive relationships between service quality and satisfaction, after collecting data using HEdPERF, a 41-items scale with 5 dimensions, distributed to 180 private university students in Nairobi, Kenya. The findings showed that the dimensions of reputation (i.e., university's image in the eyes of the public and employers) and programme issues (i.e., the importance of offering a variety of reputable academic programmes in a flexible manner) had statistically significant relationships with satisfaction. Secreto and Pamulaklakin (2015) focused on ODeL students' level of satisfaction with the Open University of Philippines student portal, developed for the purpose of facilitating students' academic journey. They sent a 14-item online survey questionnaire to undergraduate and postgraduate students at the university. They deliberately addressed students who had experienced both manual and online systems for registration, making payments, checking grades, accessing the online library, contacting their course lecturers, and the like. Generally, students were more satisfied with the online system, which they said was characterized by "reliability, accessibility, simplicity and clarity of instructions" (Secreto & Pamulaklakin, 2015, p. 40).

Similarly, Sembiring (2015) distributed a questionnaire to distance education graduates from Terbuka University in Indonesia to determine if there were any correlations between the five dimensions of SERVQUAL and satisfaction. This study showed that reliability, empathy, and responsiveness were directly related with the graduates' satisfaction when they were students at the university. Sembeiring recommended that the university focus on continuing to improve on these three dimensions of service quality so that satisfaction, which in turn had a direct impact on student retention and persistence, would be secured.

As indicated, various studies on student satisfaction were conducted with both negative and positive findings, and they provided concrete ideas on the relationship between the service quality and satisfaction. In a similar manner, this study was conducted to determine the level of student satisfaction with the different student support services offered to doctoral candidates registered at an ODeL institution. There is scant literature on doctoral students' satisfaction, with specific reference to ODeL mode of learning in Ethiopia and other African countries. Our study contributed to addressing this knowledge gap.

Theoretical Framework

This study used the gaps model (Parasuraman, et al., 1985) as an analytical framework so as to identify gaps between expectations and experiences in service quality. Examining the gaps between these two constructs served a diagnostic purpose, revealing the causes of customers' satisfaction or dissatisfaction with services and highlighting ways to sustain and improve customer satisfaction.

According to the gaps model (Parasuraman, et al., 1985), if services are found to be better than expected, then customers are satisfied. If customers' experiences are the same as their expectations, this is mere satisfaction. However, if customers' expectations exceed their experiences of the services on offer, they may experience dissatisfaction. In measuring this phenomenon, the authors of the model developed 10 service quality determinants from an exploratory study that involved different service-providing firms.

In a further study, the authors (Parasuraman et al., 1988) elaborated on the gaps model for measuring service quality by using empirical research on different service providers. Rigorous statistical methods, including Cronbach's alpha and factor analysis, were used to test and re-test the model. The procedures assisted in reducing the dimensions of service quality from 10 dimensions to 5 by removing redundancies and combining the similar ones. Test items were generated for each dimension. This resulted in a 22-item questionnaire that elaborated the following five dimensions (Parasuraman et al., 1988, p. 23):

- tangibles ("physical facilities, equipment, and appearance of personnel");
- reliability (the "ability to perform the promised service dependably and accurately");
- responsiveness ("willingness to help customers and provide prompt service");
- assurance ("knowledge and courtesy of employees and their ability to inspire trust and confidence"); and
- empathy ("caring, individualised attention the firm provides its customers").

Methods

The target population for this study was 465 doctoral students in an ODeL university operating in Ethiopia. The sample was selected through convenience sampling. The students were reached by telephone and asked to consent to and participate in the study. Those who agreed were asked for their private e-mail address to which the questionnaire, that is shown in Appendix I, was sent. As a result, 260 questionnaires were collected. Out of these, only 227 were suitable for analysis (*N* = 227). Of the 227 respondents, 85% were aged 31 to 50 years, 96% were males, and 83% were married. The respondents were enrolled in various disciplines offered by the university, including education, health, business, agriculture, and science.

The questionnaire was standardised by means of (a) inter-rater reliability (K = 0.89); (b) content validity (I-CVIs ranging from 0.88–1.00 and S-CVI = 1.00); (c) pilot testing to identify redundant items; (d) Cronbach's alpha (α ranging from 0.76–0.90 for the five dimensions); and (e) factor analysis procedures (factor loadings ranging from 0.475–0.819) in subsequent orders as stated here. These procedures, the last two of which are shown in appendix II, contributed towards the questionnaire's validity and reliability. The result of this rigorous process was a 34-item Likert scale questionnaire. The five dimensions of support served as independent variables, whereas one dimension, satisfaction, served as the dependent variable. Table 1 shows each dimension and its meaning in the context of this study.

Table 1

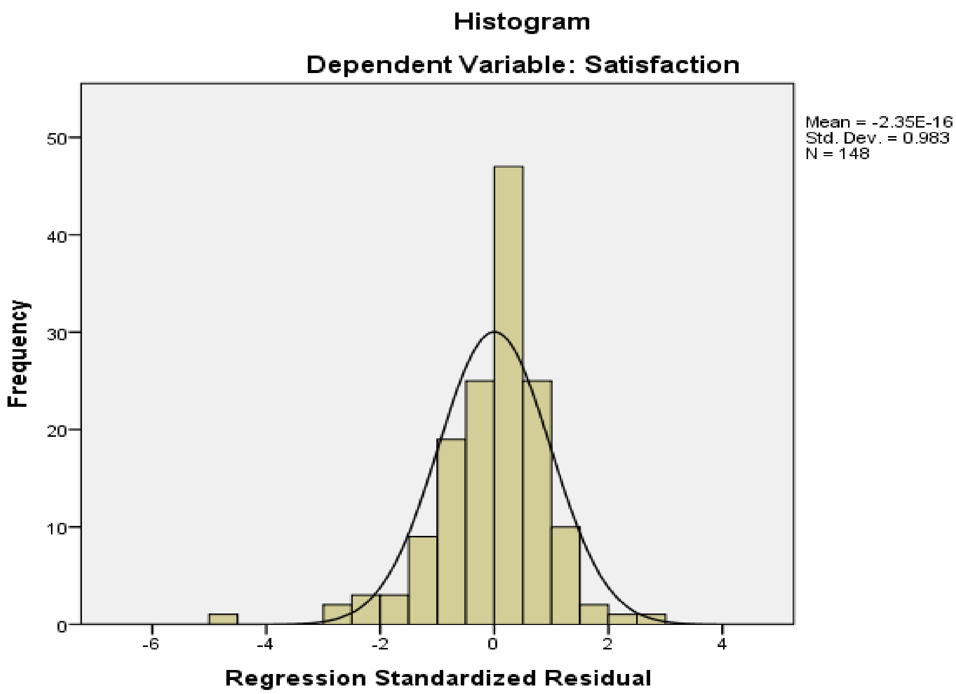
Definitions of Study Dimensions

Dimension	Meaning as used in this study
Supervision support	Timely and constructive feedback should be provided by supervisors in the process of guiding students to facilitate their academic journey.
Infrastructure	Provisions the university makes available to students in physical as well as soft formats (e.g., online library, ICT services).
Administrative support	Support schemes that relay valuable information and assistance regarding processes students should follow during application for admission and registration.
Academic facilitation	Academic support programmes that fast-track students' academic progress to decrease dropouts and increase graduation rates.
Corporate image	Issues related to how stakeholders evaluate the status or reputation of the university.
Satisfaction	Students' feelings of fulfilment that result from their perception of the services the university provides.

The data were found to be normally distributed; the peak fell on the mode of the normal curve as shown in Figure 1. Such normal distribution assures that data can be analysed using inferential statistics.

Figure 1

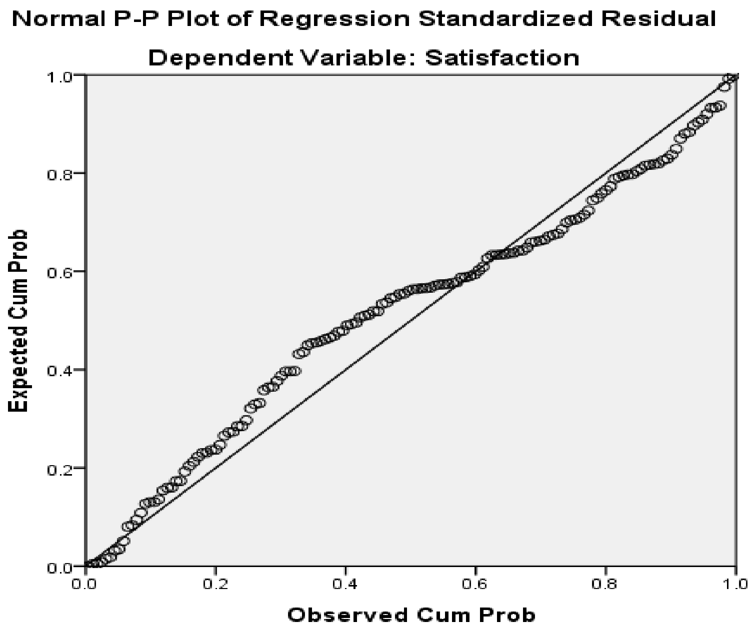
Data Distribution



In addition, as shown in Figure 2, the linearity of the data was observed before running linear regression, and the data were found to be close to the linear line. This also ensures the data is fit to be analysed through the regression model.

Figure 2

Linearity of the Relationship Between Satisfaction and the Independent Variables



The relationship between each student support dimension and satisfaction was observed by using simple (linear) regression. Moreover, to determine which dimension(s) among the five better explain(ed) students' satisfaction, stepwise regression was used to filter out and indicate which dimensions contributed most.

Data Analysis, Findings, and Discussions

The Relationship Between Five Service Quality Dimensions and Satisfaction

Using average scores of the doctoral students' expectations and experiences of service quality, the linear regression method was used to observe the relationship of each dimension with satisfaction for the first four dimensions. As shown in Table 2, each of the four dimensions of service quality (i.e., supervision support, infrastructure, administrative support, and academic facilitation) had significant negative relationships with satisfaction whereas corporate image and satisfaction were significantly and positively related.

Table 2

The Relationship Between the Five Dimensions and Satisfaction

Independent variable	Dependent variable: Satisfaction				
	Beta	*t* value	*p* value	*R*	R^2
Supervision support	-0.091	-5.544	0.001	0.377	0.138
Infrastructure	-0.045	-1.986	0.048	0.141	0.015
Administrative support	-0.118	-3.762	0.001	0.251	0.058
Academic facilitation	-0.110	-2.542	0.012	0.175	0.026
Corporate image	0.439	16.412	0.001	0.744	0.552

As shown in Table 2, supervision support explained 14% of the variance in satisfaction; the relationship between the two variables was significant and negative ($R^2 = 0.138$, $F_{(1,185)} = 30.739$, $p < 0.001$). Regarding infrastructure and satisfaction, the relationship was significant and negative. Infrastructure explained only 1.5% of the variation in satisfaction ($R^2 = 0.015$, $F_{(1,195)} = 3.95$, $p < 0.05$). Similarly, satisfaction was significantly and negatively related to the dimension of administrative support, which explained 6% of the variation in satisfaction ($R^2 = 0.058$, $F_{(1,211)} = 14.154$, $p < 0.001$). Finally, the dimension of academic facilitation explained only 2.6% of the variation in satisfaction ($R^2 = 0.026$, $F_{(1,204)} = 6.46$, $p < 0.005$). The relationship was negative and significant.

These findings show that the doctoral students' satisfaction was statistically significant and negatively related with the four dimension of service quality (i.e., supervision support, infrastructure, administrative support, and academic facilitation).

Similar findings (i.e., statistically significant negative relationships between service quality dimensions and satisfaction), were recorded by Napitupulu, et al. (2018), Sibai et al. (2021), and Wael (2015). Similarly, Datt and Singh (2021) showed that students were dissatisfied with most of the e-services on offer. Conversely, however, Kara et al. (2016), Secreto and Pamulaklakin (2015), and Ngaaso and Abbam (2016) found statistically significant positive relationships between service quality dimensions and satisfaction.

By contrast, we found that corporate image and satisfaction were significantly and positively related ($R^2 = 0.552$, $F_{(1,217)} = 269.34$, $p < 0.001$). This dimension accounted for the highest variation in satisfaction, at 55%. The two variables were strongly related, and one can conclude that the doctoral students were satisfied by the corporate image of the ODeL university. This result was in line with Khalil et al. (2018) and Ntabathia (2013).

As shown above, the relationships between satisfaction and all the five dimensions of service quality were statistically significant. However, the magnitude of relationship with the four dimensions with negative relationships was too small to make meaningful conclusions from the findings without further measuring the weight of the dimensions' contributions to satisfaction.

Dimension(s) with More Explanatory Power

We sought to identify whether any dimensions made greater contributions to explaining the students' satisfaction. This procedure was deemed helpful in focusing on issues that need improvement to guarantee students' satisfaction in the provision of student support services. Accordingly, stepwise regression was run, and the findings showed that two dimensions, namely supervision support and corporate image, stood out. Together, these dimensions explained 60% of the variance in satisfaction (R^2 = 0.599, $F_{(2,145)}$ = 110.684, p < 0.001) as shown in Table 3 below.

Table 3

Explanatory Dimensions

Independent variable	Dependent variable: Satisfaction				
	Beta	*t* value	*p* value	*R*	R^2
Corporate image	0.420	12.543	0.001	0.777	0.599
Supervision support	-0.041	-3.233	0.002		

These findings showed that the students' satisfaction was positively influenced by the university's corporate image, whereas the other dimensions were negatively related with satisfaction. Ntabathia (2013) also found that reputation was positively related with satisfaction. In addition, Khalil et al. (2018) and Sibai et al. (2021) found a negative relationship between satisfaction and responsiveness (which focuses on interaction between customers and service providers). Similarly, we found a negative relationship between satisfaction and supervision support, which included (a) acknowledging receipt of students' submissions, (b) responding to students' queries, (c) giving students adequate and timely information, (d) alerting students of useful materials, (e) giving guidance on research policies, and (f) encouraging students to work hard.

Conclusion and Recommendations

This study explored the level of Ethiopian doctoral ODeL students' satisfaction with five dimensions of student support services. We concluded that four dimensions among the five—namely supervision support, infrastructure, administrative support, and academic facilitation—were negatively related with satisfaction. The dimension of corporate image had a significant and positive relationship with satisfaction. To determine the relative contribution of the five dimensions in explaining satisfaction, stepwise regression was run; corporate image and supervision support were the greatest contributing factors. These two dimensions explained 60% of the variation in the doctoral students' satisfaction. This is a very important finding because supervision support and image/reputation are relevant to both conventional and ODeL institutions that offer doctoral degrees, hence the findings of this article give good insights internationally.

To enhance quality, we recommend that the university focuses more on the dimensions of supervision support and corporate image in order to improve doctoral students' satisfaction. We emphasise that supervision support should entail timely responses with meaningful and constructive feedback on students' proposals or chapters. This can have an important impact on keeping students active and energised with the ultimate effect of increasing the number of graduates. Moreover, guiding research students with important information regarding relevant literature, rules, and policies of research, as well as motivating and encouraging them would increase throughput. Improving the use of current technological media that facilitate ease of communication with the students would improve supervision support services and increase success rates. The university should also work on building its corporate image and that of ODeL in general, as this mode of delivery affords access to many, especially disadvantaged students who cannot access conventional modes of learning. ODeL's flexibility, affordability, use of technology in enhancing access to knowledge, and eventually bringing the qualifications home should all be emphasised, especially to assist those who work while enrolled in postgraduate education.

Other studies using the SERVQUAL or similar models could be undertaken in Africa and internationally. Future studies could identify ODeL doctoral students' levels of satisfaction and/or dissatisfaction with support services at educational institutions that employ e-learning models.

The standardized questionnaire from this study may also be adopted and modified in any way deemed important.

References

Dann, S. (2008). Applying services marketing principles to postgraduate supervision. *Quality Assurance in Education, 16*(4), 333–346. https://doi.org/10.1108/09684880810906481

Datt, G., & Singh, G. (2021). Learners' satisfaction with website performance of an open and distance learning institution: A case study. *International Review of Research in Open and Distributed Learning, 22*(1), 1–20. https://doi.org/10.19173/irrodl.v22i1.5097

Dzakiria, H. (2005). The role of learning support in open & distance learning: Learners' experiences and perspectives. *Turkish Online Journal of Distance Education, 6*(2), 95–109.

Farooq, M., Khalil-Ur-Rehman, F., Tijjani, A. D., Younas, W., Sajjad, S., & Zreen, A. (2019). Service quality analysis of private universities libraries in Malaysia in the era of transformative marketing. *International Journal for Quality Research, 13*(2), 269–284. https://doi.org/10.24874/IJQR13.02-02

Jain, R., Sinha, G., & De, S. K. (2010). Service quality in higher education: An exploratory study. *Asian Journal of Marketing, 4*(3), 144–154. https://doi.org/10.3923/ajm.2010.144.154

Kara, A. M., Tanui, E., & Kalai, J. M. (2016). Educational service quality and students' satisfaction in public universities in Kenya. *International Journal of Education and Social Science, 3*(10), 37–48.

Khalil, A. A., Ragheb, M. A., Ragab, A. A., & Elsamadicy, A. M. (2018, September 21-22). *Effect of service quality on student satisfaction on SMEs: The case of private schools in Egypt* [Conference paper]. International Conference on Management and Information Systems 2018, Bangkok, Thailand. (pp. 94–103). http://www.icmis.net/icmis18/ICMIS18CD/pdf/S184-final.pdf

Ministry of Science and Higher Education. (2020a). *Discussion document on quality human capital for quality higher education and national prosperity*. Addis Ababa.

Ministry of Science and Higher Education. (2020b). *National science policy and strategy*. Addis Ababa.

Napitupulu, D., Rahim, R., Abdullah, D., Setiawan, M. I., Abdillah, L.A., Ahmar, A. S., Simarmata, J., Hidayat, R., Nurdiyanto, H., & Pranolo, A. (2018). Analysis of student satisfaction toward quality of service facility. *Journal of Physics Conference Series*, *Indonesia, 954*(1). https://doi:10.1088/1742-6596/954/1/012019

Ngaaso, C. K., & Abbam, A. (2016). An appraisal of students' level of satisfaction of support services of distance education at the University of Education, Winneba. *Research on Humanities and Social Sciences*, *6*(10), 168–173.

Ntabathia, M. (2013). *Service quality and student satisfaction of students in private universities in Nairobi County* [Unpublished master's thesis]. University of Nairobi.

Nyenya, T., & Bukaliya, R. (2015). Comparing students' expectations with the students' perceptions of service quality provided in open and distance learning institutions in Zimbabwe's Mashonaland East Region. *International Journal of Research in Humanities and Social Studies*, *2*(4), 45–53.

O'Shea, S. E., Stone, C., & Delahunty, J. (2015). "I 'feel' like I am at university even though I am online." Exploring how students narrate their engagement with higher education institutions in an online learning environment. *Distance Education*, *36*(1), 41–58. https://doi.org/10.1080/01587919.2015.1019970

Paposa, K. K., & Paposa, S. S. (2022). From brick to click classrooms: A paradigm shift during the pandemic—Identifying factors influencing service quality and learners' satisfaction in click classrooms. *Management and Labour Studies*, 1–15. https://doi.org/10.1177/0258042X211066234

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, *49*(4), 41–50. https://doi.org/10.1177/002224298504900403

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, *64*(1), 12–40.

Secreto, P. V., & Pamulaklakin, R. L. (2015). Learners' satisfaction level with online student portal as a support system in an open and distance e-learning environment (ODeL). *Turkish Online Journal of Distance Education-TOJDE*, *16*(3), 33–47. https://doi.org/10.17718/tojde.32741

Sembiring, M. G. (2015). Student satisfaction and persistence: Imperative features for retention in open and distance learning. *Asian Association of Open Universities Journal, 10*(1), 1–11. https://doi.org/10.1108/AAOUJ-10-01-2015-B002

Sibai, M. T., Bay, B., & Rosa, R. D. (2021) Service quality and student satisfaction using ServQual model: A study of a private medical college in Saudi Arabia. *International Education Studies, 14*(6), 51–58. https://doi.org/10.5539/ies.v14n6p51

Sisay, S. (2020, January 4). Ministry seeks excellence with plan to classify public universities *Ethiopian Monitor*. https://ethiopianmonitor.com/2020/01/04/ministry-seeks-excellence-with-plan-to-classify-public-universities/

Southard, S., & Mooney, M. (2015). A comparative analysis of distance education quality assurance standards. *The Quarterly Review of Distance Education*, *16*(1), 55–68.

Teeroovengadum, V., Kamalanabhan, T. J. & Seebaluck, A. K. (2016). Measuring service quality in higher education. *Quality Assurance in Education*, *24*(2), 244–258. https://doi.org/10.1108/QAE-06-2014-0028

Tsige G. A. (2016). *Ensuring the quality of doctoral student support services in open distance learning* [Unpublished doctoral thesis]. University of South Africa.

Van Deuren, R., Tsegazeab, K., Seid, M., & Wondimu W. (2016). Ethiopian new public universities: Achievements, challenges and illustrative case studies. *Quality Assurance in Education*, 24(2), 158–172. https://doi.org/10.1108/QAE-12-2014-0054

Wael, T. (2015). Using SERVQUAL model to assess service quality and students' satisfaction in Pavia University, Italy. *International Journal of Research in Business Studies and Management*, *2*(3), 24–31.

Wodwossen, T. (2020, October 01). What next for a partially differentiated HE system? *University World News*, Issue No. 285. https://www.universityworldnews.com/post.php?story=20200929080901365

Appendix A: Final Questionnaire

Dear Colleague,

Thank you so much for your willingness to complete this questionnaire. The questionnaire involves two types of expected responses. First, please indicate your expectations of the student support services that should be provided. Second, respond regarding your actual experiences of the student support services provided to you since you enrolled. Kindly respond frankly and accurately.

Please record your responses regarding student support services in columns A and B.

Indicate your expectations in column A and your actual experiences in column B.

Respond using the following scale: 0 = None, 1 = Little, 2 = Some, 3 = Much, and 4 = Very Much

Please highlight/underline/encircle the one response that best describes your views in both columns A and B.

Service	A To what extent do you feel that supervisors should provide this type of service?	B In your experience, to what extent do supervisors actually provide this type of service?
1) give clear comments on students' submissions like proposals or chapters	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
2) acknowledge the receipt of students' submissions without delay	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
3) give adequate information to students on ethical clearance procedures	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
4) alert students of useful resources related to the students' doctoral projects	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
5) communicate with students via different technological media like e-mail, Skype, chatting, and the like	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
6) give guidance to students regarding policies and rules (e.g., plagiarism, structural requirements of the thesis) that govern doctoral studies	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
7) respond to students' submissions within an agreed upon period of time	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much

8) periodically encourage students to make the required submissions (e.g., chapters)	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
9) be fairly consistent over time in the comments they give to students unless new developments in the field dictate otherwise	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
10) provide information about research fund possibilities	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
11) ensure that the library is rich in e-journal and e-book collections	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
12) ensure that the online library is accessible seven days a week throughout the year	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
13) make myLife e-mail account user-friendly	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
14) ensure that ICT resources are up-to-date	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
15) provide technical assistance when students face ICT-related problems	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
16) ensure that library possesses a wide range of subject-related materials	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
17) ensure that library is equipped with recent research books	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
18) make computer labs accessible to students	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much

19) Centre be in a location accessible to students	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
20) provide information on doctoral applications in both hard copy and digital (online) format	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
21) provide a response regarding admission decisions on first applications within a reasonable period	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
22) ensure that registration and re-registration processes are user-friendly	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
23) ensure that decisions of departmental higher degrees committees on doctoral students' proposals are communicated to students as quickly as possible	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
24) provide information about administrative procedures involving doctoral students (e.g., intention to submit, library procedures)	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
25) provide training to students on how to develop a doctoral proposal	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
26) make sure doctoral workshops/seminars/training address issues are relevant to the research projects students are involved in	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
27) provide training programs in the form of seminars/colloquia for students who	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much

have progressed beyond the proposal phase		
28) provide training on data analysis software packages (e.g., SPSS, Atlas-ti)	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
29) the university is a leading open distance e-learning university	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
30) graduates of this university have a favourable image in Ethiopia	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
31) university grants doctoral degrees that are of international standard	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
32) Ethiopians who have graduated from this university are proud of their qualifications	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
33) I recommend this university to friends/relatives/family members	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much
34) overall, I am satisfied with the services rendered by the university	0 None 1 Little 2 Some 3 Much 4 Very Much	0 None 1 Little 2 Some 3 Much 4 Very Much

Appendix B: Factor Loadings and Cronbach's Alpha Test Results

Questionnaire Items	Support service component				
	Supervision support	Infrastructure	Administrative support	Academic facilitation	Corporate image
Clear comments from supervisors	0.751				
Supervisors acknowledge receipt of students' submissions	0.738				
Information on ethical clearance procedures	0.642				
Alerting students on useful resources	0.702				
Using different technological media for communication	0.715				
Guidance on governing rules and policies	0.732				
Supervisors' timely responses to students' submissions	0.759				
Supervisors periodically encourage their students	0.738				
Supervisors' comments consistent over time	0.727				
Supervisors give information on research fund possibilities	0.726				
	$\alpha = 0.90$				
Library contains e-book and e-journal collections		0.661			
Online library accessible throughout the year		0.705			
ICT resources up-to-date		0.664			
Assistance for ICT-related challenges		0.612			
Centre library stocking subject-relating materials		0.708			
Centre library stocks recent research books		0.649			
Accessibility of computer labs		0.597			
Accessibility of location		0.484			

Questionnaire Items	Support service component				
	Supervision support	Infrastructure	Administrative support	Academic facilitation	Corporate image
		α = 0.84			
User-friendliness of myLife e-mail			0.475		
Provision of information on doctoral application			0.671		
Responses on admission decisions			0.713		
User-friendliness of registration and re-registration			0.769		
Time span in communicating HDC decisions on proposal			0.547		
Provision of information on administrative procedures			0.551		
			α = 0.78		
Doctoral proposal development training				0.664	
Relevance of training to students' research				0.735	
Provision of programs for post-proposal students				0.711	
Training on data analysis software				0.648	
				α = 0.76	
University is a leading ODL university					0.781
Public image of graduates					0.819
Degree meets international standard					0.761
Graduates have pride in their qualifications					0.816
					α = 0.83

Athabasca University

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Translating and Validating the Community of Inquiry Survey Instrument in Brazil

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Abstract

Massive open online courses (MOOCs) have emerged as an affordable way to distribute knowledge and democratize education. The examination of online courses calls for theoretical models and instruments that contemplate its particularities. The community of inquiry (CoI) framework has been used in several studies to analyze the effectiveness of online education and hybrid education, including MOOCs. This study aimed to translate and validate the Community of Inquiry Survey instrument (Arbaugh et al., 2008) into Brazilian Portuguese, and used a two-stage methodological design for translating and validating a questionnaire. In the first stage, we carried out translation, back-translation, and cross-cultural adaptation. We translated the 34 items while maintaining the survey's original format. In the expert evaluation phase, all items were considered understandable and essential for inclusion in the Brazilian Portuguese version of the CoI instrument. In the second stage, a prospective cross-sectional study was conducted to validate the questionnaire, and data was collected from participants completing the *Nursing Assessment* MOOC available on the Lúmina platform. A total of 690 responses were gathered. The resulting instrument produced excellent results, and the three presences achieved high reliability indexes, clearly indicating their adequacy. Furthermore, this study proved the validation of the CoI instrument, maintaining the three-factor structure previously reported in the literature corresponding to the three presences: teaching, social, and cognitive presence. We recommend further studies to evaluate the need for excluding or altering cognitive presence items.

Keywords: Instrument validation, community of inquiry, exploratory factor analysis, massive open online courses, instrument translation, Brazilian Portuguese

Translating and Validating the Community of Inquiry Survey Instrument in Brazil

Massive open online courses (MOOCs) have emerged as a way to distribute knowledge produced by renowned institutions, and to democratize teaching on different platforms in an affordable and low-cost manner (Barba et al., 2018). Moreover, during the COVID-19 pandemic, MOOCs became an important educational tool with increased enrollments and flexibility, given that several providers reduced fees (Impey & Formanek, 2021). Even in a post-pandemic projection, MOOCs can be considered a staple tool. They can also provide learning experiences for higher education students, such as learning with minimal supervision and instructor-learner interaction. Furthermore, universities can maintain this teaching format as a replacement for or complement to offerings in some theoretical disciplines (Safri et al., 2020).

However, the examination of online courses requires theoretical models and instruments that contemplate their particularities. The community of inquiry (CoI) framework is a theoretical model that has guided the development of online learning and evaluation of its effectiveness (Garrison et al., 2000). It was deliberately intended to guide the development of online and computer-mediated education.

The CoI was based on the ideas of John Dewey, and has constituted an important reinforcement to the use of constructivist theories of learning in higher education (Garrison et al., 2000). The CoI model considered three elements: teaching presence, social presence, and cognitive presence (Garrison et al., 2000). Teaching presence consists of granting, facilitating, and directing cognitive and social processes, to achieve learning outcomes with personal meaning and educational value (Garrison et al., 2000). Social presence is the ability of students to project themselves socially and emotionally, and to be perceived as real people in mediated communication (Garrison et al., 2000). Finally, cognitive presence is the extent in which students are able to construct and confirm meaning through sustained reflection and discourse, which allows a continuous evaluation of the organization of critical thinking and reflections throughout the course (Garrison et al., 2000, 2001).

Developed by Arbaugh et al. (2008), the CoI Survey instrument consisted of 34 items with a 5-point Likert scale, designed to measure students' perceived levels in teaching presence, social presence, and cognitive presence. In 2007, this research instrument was applied in four different institutions located in the United States and Canada. The study participants were enrolled in graduate courses in education or administration. A total of 287 students volunteered to answer the survey, with a response rate of 43% (Arbaugh et al., 2008). In 2008, the Community of Inquiry Survey instrument was formally proposed and validated to strengthen and expand the use of the CoI.

Consistent with the design of the instrument, items 1 to 13 (teaching presence) loaded more strongly into factor 1. Items 14 to 22 (social presence) had more influence on factor 2. Finally, items 23 to 34 (cognitive presence) had more influence on factor 3. Cronbach's alpha yielded internal consistencies equal to 0.94 for teaching presence, 0.91 for social presence, and 0.95 for cognitive presence (Arbaugh et al., 2008).

This instrument has been used in different countries, and has been translated into and validated in many languages in order to expand its use (Ma et al., 2017; Moreira et al., 2013; Olpak & Kiliç Çakmak, 2018; Velázquez et al., 2019; Yu & Richardson, 2015). Up to now, the instrument has not yet been validated and adapted to Brazilian Portuguese, limiting its use in this language, which is an imminent need for the development of research evaluating distance education.

The CoI has been used in several studies to analyze the effectiveness of online education and hybrid education; it has also been used to evaluate MOOCs. These studies explored teaching, social, and cognitive presence in contexts beyond strictly instructional and impersonal models to those that enable interaction (Caskurlu et al., 2020; Stenbom, 2018; Velázquez et al., 2019; Yu & Richardson, 2015). However, despite confirming the potential for the use of the CoI to provide a better understanding of learning processes in MOOCs, it is still necessary to explore how course design affects the three CoI presences (Kovanovic et al., 2018).

In nursing teaching, we found reports of the CoI being used in hybrid education at undergraduate and graduate levels, characterized by the development of collaborative activities with exchanges between participants, especially using discussion forums (Miils et al., 2016; Phillips et al., 2013; Stephens & Hennefer, 2013). In a study to investigate the level of knowledge of the CoI structure and its applicability to the design of online and hybrid courses in Australian higher education nursing schools, the results showed that instructors classified the three presences (i.e., teaching, social, and cognitive) of the CoI framework as applicable to teaching nursing online (Smadi et al., 2019). Also, instructors who were familiar with the CoI structure reported that they would probably recommend the structure of the CoI to a colleague (Smadi et al., 2019).

This current study was justified by the need to use instruments cross-culturally and adapted to other languages, in order to expand their applicability for other cultures. Specifically, this study aimed to translate and validate the CoI Survey instrument for Brazilian Portuguese.

Method

Study Design

We followed Beaton et al.'s (2000) methodological design for translating and validating a questionnaire. Before starting the process, e-mail consent was obtained to translate and validate the CoI Survey instrument from English into Brazilian Portuguese. In the first stage, translation, back-translation, and cross-cultural adaptation were conducted. In the second stage, a prospective cross-sectional survey was conducted to validate the translated questionnaire.

First Stage: Translating and Adapting the Questionnaire to Portuguese

The first translation stage was performed by two independent translators who translated the CoI to Portuguese. The researchers then synthesized the two versions, resulting in a single Portuguese version. In the back-translation step, the Portuguese version was translated back into English by two others translators who both had mastery of English. For one of the translators, English was their mother tongue. All items were evaluated for semantic, idiomatic, cultural, and conceptual equivalences. The final Portuguese version was composed by the researchers' consensus.

To finish this stage, the Portuguese questionnaire, translated in the online format, was made available as a pre-test to a convenience sample of 30 nursing students participating in the *Nursing Assessment* MOOC conducted by the Universidade Federal do Rio Grande do Sul and hosted on the Lúmina platform.

Second Stage: Questionnaire Validation Process

To validate the questionnaire, data was collected from the *Nursing Assessment* MOOC available on the Lúmina platform using an online form. Between September 2019 and February 2020, 1,063 students responded to the research instrument. Incomplete responses were excluded, resulting in a total of 690 responses.

Data Analysis

Exploratory factor analysis was performed using the Statistical Package for Social Sciences (SPSS, version 21). The variables were described by mean and standard deviation. Cronbach's alpha coefficient was used to determine the internal consistency of the instrument. In evaluating the instrument structure along three subscales, factor analysis by principal components and with varimax rotation was applied. To verify the adequacy of the sample for factor analysis, the Keyser-Meyer-Olsen (KMO) measurement was obtained. The association between the domains (i.e., teaching, social, and cognitive presence) was measured by Pearson's correlation test. A 5% significance level was adopted ($p < 0.05$).

Ethical Issues and Permissions

All the procedures adopted in this study complied with the criteria on Ethics in Research with Human Beings, according to Resolution no. 466 (December 12, 2012) of the National Health Council of Brazil (Government of Brazil, 2012). This research was approved by the Research Ethics Committee of the Universidade Federal do Rio Grande do Sul.

Results

First Stage: Translating the Questionnaire

The 34 items of the Arbaugh et al. (2008) survey were translated without any difficulty while maintaining the original format (**Appendix)**.

Second Stage: Validating the Questionnaire

The sample of 690 resulted in a KMO measurement of 0.96. The sample size (N = 690) for this study was considered adequate, meeting the recommendation of 10 or more respondents per item of the questionnaire under validation (Nunnally, 1978). The measure of adequacy of the KMO sample demonstrated that the factor analysis was reliable. Table 1 shows the total explained variance of the main components. Specifying a three-factor solution accounts for 65.1% of the total variance. More than half (57.4%) of the total variation of this three-factor solution was attributed to the first two factors. Component analysis suggested a fourth additional factor; however, it did not show as significant variation as did the first three factors, which was also apparent in the sedimentation graph (Figure 1).

Table 1

Total Variance for the CoL Instrument Explained by Factor Analysis with Varimax Rotation

	Initial own values		
Factor	Total	% variance	% cumulative
1	15.554	45.747	45.747
2	3.973	11.684	57.431
3	2.620	7.707	65.138
4	1.323	3.891	69.029

Figure 1

Sedimentation Graph of Factor Analysis of CoL Instrument

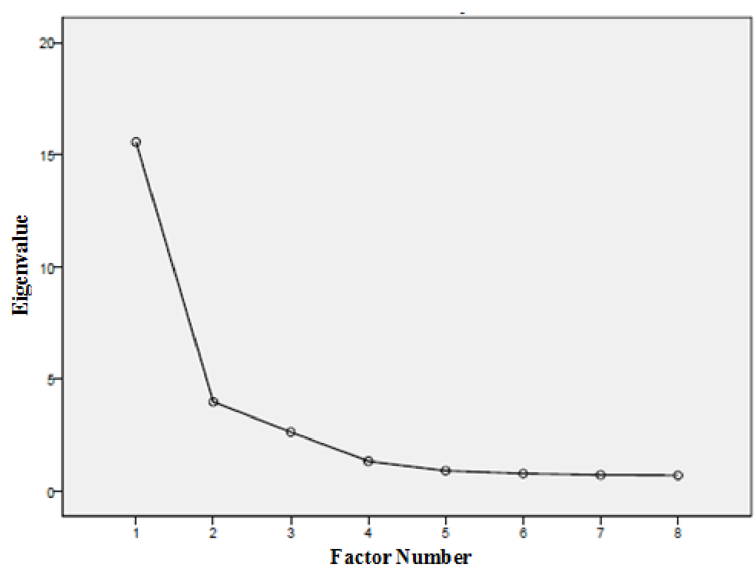

Table 2 lists the load factor for each of the 34 items of the CoI in terms of the three factors. Items 1 to 13 (teaching presence) had more influence on factor 2, and items 14 to 22 (social presence) had more influence on factor 1. Items 23 to 34 (cognitive presence) had more influence on factor 3, except for items 27 and 28 that presented stronger loads for factor 1. Cronbach's alpha produced internal consistencies of 0.94 for teaching presence, 0.95 for social presence, and 0.91 for cognitive presence. The three domains showed a positive correlation with each other (Table 3).

Table 2

Component Rotation Matrix for CoI Instrument

	Factor

		1	2	3
1.	The instructor clearly communicated important course topics.	.004	**.681**	.337
2.	The instructor clearly communicated important course goals.	−.077	**.694**	.299
3.	The instructor provided clear instructions on how to participate in course learning activities.	.011	**.730**	.332
4.	The instructor clearly communicated important due dates/time frames for learning activities.	.144	**.703**	.225
5.	The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.	.192	**.774**	.247
6.	The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	.156	**.772**	.315
7.	The instructor helped to keep course participants engaged and participating in productive dialogue.	.359	**.752**	.113
8.	The instructor helped keep the course participants on task in a way that helped me to learn.	.300	**.751**	.234
9.	The instructor encouraged course participants to explore new concepts in this course.	.336	**.713**	.237
10.	Instructor actions reinforced the development of a sense of community among course participants.	.409	**.720**	.157
11.	The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	.318	**.713**	.237
12.	The instructor provided feedback that helped me understand my strengths and weaknesses relative to the course's goals and objectives.	.457	**.658**	.121
13.	The instructor provided feedback in a timely fashion.	.456	**.643**	.087
14.	Getting to know other course participants gave me a sense of belonging in the course.	**.812**	.228	.126
15.	I was able to form distinct impressions of some course participants.	**.796**	.221	.129
16.	Online or Web-based communication is an excellent medium for social interaction.	**.498**	.261	.309
17.	I felt comfortable conversing through the online medium.	**.726**	.194	.230
18.	I felt comfortable participating in the course discussions.	**.854**	.161	.184
19.	I felt comfortable interacting with other course participants.	**.863**	.183	.172
20.	I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	**.871**	.161	.121
21.	I felt that my point of view was acknowledged by other course participants.	**.870**	.151	.132

22. Online discussions help me to develop a sense of collaboration.	**.846**	.163	.212
23. Problems posed increased my interest in course issues.	.208	.259	**.638**
24. Course activities piqued my curiosity.	.116	.290	**.782**
25. I felt motivated to explore content-related questions.	.079	.299	**.762**
26. I used a variety of information sources to explore problems posed in this course.	.380	.110	**.397**
27. Brainstorming and finding relevant information helped me resolve content-related questions.	**.569**	.192	.445
28. Online discussions were valuable in helping me appreciate different perspectives.	**.730**	.187	.316
29. Combining new information helped me answer questions raised in course activities.	.424	.166	**.628**
30. Learning activities helped me construct explanations/solutions.	.210	.281	**.744**
31. Reflection on course content and discussions helped me understand fundamental concepts in this class.	.304	.231	**.699**
32. I can describe ways to test and apply the knowledge created in this course.	.252	.219	**.710**
33. I have developed solutions to course problems that can be applied in practice.	.247	.210	**.697**
34. I can apply the knowledge created in this course to my work or other non-class related activities.	.060	.219	**.751**

Note. Observation: Extraction method: Principal Component Analysis.

Table 3

Correlations Between the CoI Instrument Domains

Domain	Teaching presence	Social presence	Cognitive presence
Teaching presence	1	.573**	.620**
Social presence	.573**	1	.582**
Cognitive presence	.620**	.582**	1

Note. Pearson correlation, significant at level 0.01** (2 ends).

Discussion

The suggestion of adding a fourth factor to the model has been discussed since the original validation of the instrument. However, as well as the data found in this study, the sedimentation graph fails to inform the possibility of a fourth additional factor, considering the intense decrease in the magnitude of the eigenvalues of the first and second factors (Arabaugh et al., 2008). The structure of three factors was also maintained and confirmed in the Korean version; this study used exploratory and confirmatory factor analysis to evaluate its validity found 63.82% of the explanation of the structure within three factors (Yu & Richardson, 2015). Despite keeping the initial structure, the Chinese version of the instrument suggested additional emphasis on teaching presence (Ma et al., 2017). In a study conducted specifically with MOOCs, the analysis suggested a six-factor model to better adjust the data (Kovanovic et al., 2018).

We observed that two items of cognitive presence, items 27 (debating and searching for relevant information helped us solve content-related issues) and 28 (online discussions were valuable in helping us understand different perspectives), pointed more strongly to social presence. In part, this phenomenon can be explained by the MOOC course design. It is possible that discrepancies between the dynamics of traditional online courses and MOOCs affect students' perceptions of the three presences of the CoI (Kovanovic et al., 2018); studies have suggested that further research is needed into the role of social presence in MOOCs (Poquet et al., 2018, Stranach, 2017). However, in the validation for the Korean language, conducted with online graduate courses, the authors also suggested the removal of two items from social presence, as well as one item of teaching presence, resulting in a model of 31 items (Yu & Richardson, 2015). On the other hand, the Turkish version of the instrument maintained the 34-item structure (Olpak & Kiliç Çakmak, 2018).

Conclusion and Limitations

This study aimed to translate and validate the CoI Survey for Brazilian Portuguese. The resulting instrument produced excellent results, and the three presences achieved high reliability indicators, demonstrating their adequacy.

Furthermore, this study further validated the CoI instrument, maintaining the structure of three factors—teaching presence, social presence, and cognitive presence. Using the validated and adapted CoI makes it possible to increase its use in the Brazilian context in order to support the development and evaluation of distance education in Brazil. In addition, applying the instrument translated to Brazilian Portuguese allows for further studies to compare different educational realities. We recommend conducting studies to evaluate the need to exclude or alter cognitive presence items.

As a limitation of this study, we emphasize that the validation of the instrument translated into Brazilian Portuguese took place in a single MOOC and not in a blended format. Thus, we suggest further studies to use and evaluate the instrument validated in other online course formats.

References

Arbaugh, J. B., Cleveland-Innes, M., Diaz, S. R., Garrison, D. R., Ice, P., Richardson, J. C., & Swan, K. P. (2008). Developing a community of inquiry instrument: Testing a measure of the Community of Inquiry framework using a multi-institutional sample. *Internet and Higher Education, 11*(3-4), 133–136. https://doi.org/10.1016/j.iheduc.2008.06.003

Barba, P. G., Kennedy, G. E., & Ainley, M. D. (2018). The role of students' motivation and participation in predicting performance in a MOOC Motivation and participation in MOOCs. *Journal of Computer Assisted Learning, 32*(3), 218–231. https://doi.org/10.1111/jcal.12130

Beaton, D. E., Bombardier, C., Guillemin, F., & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine, 16*(2), 3186–3191. https://doi.org/10.1097/00007632-200012150-00014

Caskurlu, S., Maeda, Y., Richardson, J. C., & Lv, J. (2020). A meta-analysis addressing the relationship between teaching presence and students' satisfaction and learning. *Computers and Education*, *157*(September 2019), 103966. https://doi.org/10.1016/j.compedu.2020.103966

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2-3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education, 15*(1), 7–23. https://doi.org/10.1080/08923640109527071

Government of Brazil. (2012). *Resolução nº 466, de 12 de dezembro de 2012* [Resolution No. 466, December 12, 2012]. National Health Council, Ministry of Health. http://www.conselho.saude.gov.br/web_comissoes/conep/index.html

Impey, C., & Formanek, M. (2021). MOOCS and 100 days of COVID: Enrollment surges in massive open online astronomy classes during the coronavirus pandemic. *Social Sciences & Humanities Open, 4*(1), 100177. https://doi.org/10.1016/j.ssaho.2021.100177

Kovanović, V., Joksimović, S., Poquet, O., Hennis, T., Čukić, I., de Vries, P., Hatala, M., Dawson, S., Siemens, G., & Gaševićc, D. (2018). Exploring communities of inquiry in massive open online courses. *Computers & Education, 119*, 44–58. https://doi.org/10.1016/j.compedu.2017.11.010

Ma, Z., Wang, J., Wang, Q., Kong, L., Wu, Y., & Yang, H. (2017). Verifying Causal Relationships Among the Presences of the Community of Inquiry Framework in the Chinese Context. *The International Review of Research in Open and Distributed Learning*, *18*(6). https://doi.org/10.19173/irrodl.v18i6.3197

Moreira, J. A., Ferreira, A. G., & Almeida, A. C. (2013). Comparing communities of inquiry of

Portuguese higher education students: One for all or one for each? *Open Praxis, 5*(2), 165–178. http://dx.doi.org/10.5944.

Mills, J., Yates, K., Harrison, H., Woods, C., Chamberlain-Salaun, J., Trueman, S., & Hitchins, M. (2016). Using a community of inquiry framework to teach a nursing and midwifery research subject: An evaluative study. *Nurse Education Today, 43*, 34–39. https://doi.org/10.1016/j.nedt.2016.04.016

Olpak, Y. Z., & Kiliç Çakmak, E. (2018). Examining the reliability and validity of a Turkish version of the community of inquiry survey. *Online Learning, 22*(1), 147–161. https://doi.org/10.24059/olj.v22i1.990

Phillips, D., Forbes, H., & Duke, M. (2013). Teaching and learning innovations for postgraduate education in nursing. *Collegian, 20*(3), 145–151. https://doi.org/10.1016/j.colegn.2012.05.003

Poquet, O., Kovanović, V., de Vries, P., Hennis, T., Joksimović, S., Gašević, D., & Dawson, S. (2018). Social presence in massive open online courses. *International Review of Research in Open and Distributed Learning, 19*(3), 43–68. https://doi.org/10.19173/irrodl.v19i3.3370

Safri, S. N. W., Mohi, Z. & Hanafiah, M. H. (2020). Massive open online course (MOOC): Our saviour during COVID-19 pandemic? *Journal of Tourism, Hospitality & Culinary Arts, 12*(3), 120–128. fhtm.uitm.edu.my/images/jthca/Vol12Issue3/Chap_8.pdf

Smadi, O., Parker, S., Gillham, D., & Müller, A. (2019). The applicability of community of inquiry framework to online nursing education: A cross-sectional study. *Nurse Education in Practice, 34*, 17–24. https://doi.org/10.1016/j.nepr.2018.10.003

Stenbom, S. (2018). A systematic review of the community of inquiry survey. *Internet and Higher Education*, *39*(June), 22–32. https://doi.org/10.1016/j.iheduc.2018.06.001

Stephens, M., & Hennefer, D. (2013). Internationalising the nursing curriculum using a community of inquiry framework and blended learning. *Nurse Education in Practice, 13*(3), 170–175. https://doi.org/10.1016/j.nepr.2012.08.010

Stranach, M. (2017). *Social presence in two massive open online courses (MOOCs): A multiple case study* [Unpublished doctoral thesis]. University of Calgary. http://dx.doi.org/10.11575/PRISM/27816

Velázquez, B. B., Gil-Jaurena, I., & Encina, J. M. (2019). Validation of the Spanish Version of the 'Community of Inquiry' survey. *Revista de Educación a Distancia, 59*(4). http://dx.doi.org/10.6018/red/59/04

Yu, T. & Richardson, J. C. (2015). Examining reliability and validity of a Korean version of the community of inquiry instrument using exploratory and confirmatory factor analysis. *The Internet and Higher Education, 25*, 45–52. https://doi.org/10.1016/j.iheduc.2014.12.004

Appendix: Dimensions and Items of the Brazilian CoI Survey Instrument - Comunidade Investigativa

Presença de Ensino

Planejamento e Organização

1. O instrutor informou claramente os tópicos importantes do curso.
2. O instrutor informou claramente os objetivos principais do curso.
3. O instrutor apresentou instruções claras sobre como participar das atividades de aprendizagem do curso.
4. O instrutor informou claramente as datas e os prazos principais para entrega das atividades de aprendizagem.

Facilitação

5. O instrutor auxiliou a identificar áreas de concordância e discordância nos tópicos do curso que me ajudou a aprender.
6. O instrutor, ao orientar a atividade, auxiliou na compreensão dos tópicos do curso de forma que ajudou a esclarecer meu pensamento.
7. O instrutor auxiliou a manter os participantes do curso envolvidos e participativos em diálogos produtivos.
8. O instrutor auxiliou a manter os participantes do curso nas atividades de forma que me ajudou a aprender.
9. O instrutor incentivou os participantes a explorarem novos conceitos neste curso.
10. As ações do instrutor reforçaram o desenvolvimento do senso de comunidade entre os participantes do curso.

Instrução de direcionamento

11. O instrutor auxiliou em direcionar a discussão para questões relevantes de forma que me ajudou a aprender.
12. O instrutor forneceu retorno que me ajudou a compreender meus pontos fortes e fracos.
13. O instrutor forneceu retorno em tempo hábil.

Presença social

Expressão afetiva

14. Ter contato com os demais participantes deu-me a sensação de pertencimento no curso.
15. Eu fui capaz de formar impressões distintas sobre alguns dos participantes do curso.
16. A comunicação online ou através da internet é um excelente meio para interação social.

Comunicação aberta

17. Eu me senti confortável me comunicando online.
18. Eu me senti confortável participando das discussões do curso.
19. Eu me senti confortável interagindo com outros participantes do curso.

Coesão do grupo

20. Eu me senti confortável em discordar de outros participantes do curso, mantendo a sensação de confiança.
21. Eu senti que meu ponto de vista foi reconhecido por outros participantes do curso.
22. As discussões online me auxiliaram a desenvolver a sensação de colaboração.

Presença cognitiva

Evento disparador

23. A proposição de problemas aumentou o meu interesse nas questões de curso.
24. As atividades do curso instigaram minha curiosidade.
25. Eu me senti motivado a explorar questões relacionadas ao conteúdo.

Exploração

26. Eu utilizei várias fontes de informação para explorar problemas propostos neste curso.
27. O debate e a busca por informações relevantes me ajudaram a resolver questões relacionadas ao conteúdo.
28. As discussões online foram valiosas para me ajudar a valorizar diferentes perspectivas.

Integração

29. A combinação de novas informações me ajudou a responder questões que surgiram em atividades do curso.
30. As atividades de aprendizagem me ajudaram a construir explicações/soluções.
31. A reflexão sobre o conteúdo do curso e as discussões me ajudaram a compreender os conceitos fundamentais das aulas.

Resolução

32. Eu posso descrever maneiras para testar e aplicar o conhecimento gerado neste curso.
33. Eu desenvolvi soluções para os problemas do curso que podem ser aplicadas na prática.
34. Eu posso aplicar o conhecimento gerado neste curso no meu trabalho ou em outras atividades não relacionadas ao curso.

Escala de Likert:

1 = discordo totalmente
2 = discordo
3 = neutro
4 = concordo
5 = concordo totalmente

International **R**eview of **R**esearch in **O**pen and **D**istributed **L**earning
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Book Review: An Introduction to Open Education

Editors: Arts, Y., Call, H., Cavan, M., Holmes, T. P., Rogers, J., Tuiloma, S. H., West, L., & Kimmons, R. (2021). An Introduction to Open Education. EdTech Books. https://edtechbooks.org/open_education

Reviewed by: Michael Paskevicius, University of Victoria, Canada

Review date: February 17, 2022

An Introduction to Open Education joins a collection of over 250 open textbooks on edtechbooks.org. The collection there is a significant contribution of open textbooks specifically focused on education, technology-enabled learning, learning design, and research. All of the texts are freely available online with open licenses that enable reuse and remix by educators, students, and self-learners.

The text under review, *An Introduction to Open Education*, features contributions from several authors, many of them well established in the open education research and practice literature. The book has been edited and compiled by eight authors and appears to be a collaborative project created by faculty and graduate students at Brigham Young University. It includes sections on foundations of open education, research into open education, future directions for open education, and obstacles to the use of open educational resources (OER). The book concludes with appendices including an author list, glossary and keyword list, and a useful hyperlinked index with links to key issues discussed in the text.

The book begins with a section outlining the foundations of open education, most specifically focussed on OER. A definition of the term is aptly described to have relevance to all individuals, be it learners in formal education settings, educators, or self-directed learners. This usefully widens the context and applicability of OER to all individuals. This section of the book contains excellent material on copyright, including discussions of open licensing, fair use, and the public domain. Overall, this foundation section provides an excellent overview for those new to OER and open licences, and clearly explains why these are important to support increasing access to teaching and learning.

The foundation section includes a useful discussion on file formats and technical considerations for ensuring OER are useable. This material resonated in particular with me as a result of my experiences supporting educators and teacher candidates as they identify and attempt to use and remix OER. File formats and technical issues can at times cause friction in the use of OER, and I believe this was a useful addition to the book's foundation section. I appreciated this discussion on file formats and the digital literacies needed to navigate and combine different media types to create new OER. The framework guiding this discussion, known as ALMS, suggests that publishers and OER creators consider access to the necessary editing tools, level of editing expertise, meaningfully editable formats, and self-sourced materials. The ALMS framework provides a thoughtful lens for creators to consider when making OER available as well as a way to scrutinize OER in terms of reusability.

The OER research section tackles many of the issues related to OER, including resource selection, quality assurance, continuous improvement, and the efficacy of OER. Many of the chapters appear to be adaptations of peer-reviewed studies previously published in a variety of open access journals and include links to the previous versions as published. The chapter provides a thoughtful collection of the topical research into OER.

The future directions section includes four chapters focused on open pedagogy, again compiled from previously published articles or blog posts. I am not entirely convinced that open pedagogy represents a future direction; from the content of this section, it appears that the authors may share this view. Open pedagogy is very much a current path for OER as many educators and students are taking up the practices associated with open education in exciting ways. There may have been a missed opportunity here to showcase the research and work being done in and around open pedagogy and in doing so, include more diverse voices and perspectives in this section.

Structurally, I believe that the content in the final sections on recognizing and overcoming obstacles as well as assumptions and challenges of open scholarship could have been included in the future directions section. The recognizing and overcoming obstacles section contains only a single chapter. As it stands, the issues around obstacles and barriers to OER use, as well as that of open scholarship, may be considered future directions (and/or current trends) as posited in the previous section.

The book concludes with a section including slide desks and video presentations from a selection of PhD students at Brigham Young University. I would have liked to see this section introduced in more detail, as well as provide information about how the student contributions came to be part of the book. Many of the videos included transcripts both within the video and provided as part of the text. These presentations provide a nice addition to the text, showcasing various student perspectives.

Leveraging the online format of this textbook, it includes several videos, slide decks, links to further resources, lists of common questions, H5P interactives, and chapter feedback surveys. These enhance the book by providing additional resources, interactivity, and feedback mechanisms.

Overall, *An Introduction to Open Education* would benefit from more consistency around citation practices throughout the chapters. While some chapters contained a reference list in APA format, others adopted footnotes, while still others used hypertext links directly in the text. Consistency across the collection of chapters would be a useful improvement to this resource. A reference list by chapter would also be a valuable addition to the book index.

Generally, this book adds to our understanding of open education, most specifically focused on an understanding of OER and the issues related to their use. Particularly, this resource serves as a valuable introductory text for those new to open education; it would serve graduate students and faculty new to these practices and approaches very well.

The growing collection of EdTechBooks is well worth a review for anyone working, teaching, or studying in the area of education, technology-enabled learning, learning design, or research. *An Introduction to Open Education* is a great addition to the collection. I imagine this text, like others in the collection, will evolve as it is taken up, revised, and progresses further, informed by the feedback mechanisms built in through chapter surveys and remixability provided by the open license and friction free access by educators, students, and self-learners.

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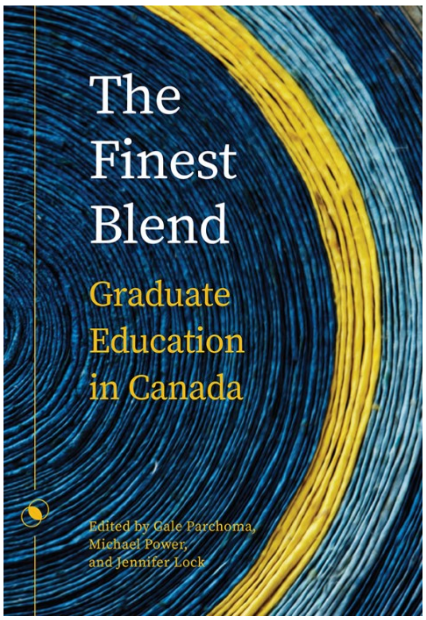
Book Review:
The Finest Blend: Graduate Education in Canada



Editors: Gale Parchoma, Michael Power, and Jennifer Lock
(Athabasca University Press, 2020, 375 pages) ISBN: 9781771992770

Reviewed By: Ulfah Marifah

The blended and online learning ecosystem is a complex multi-stakeholder environment. Not until the unprecedented COVID-19 pandemic hit did technology-enabled education become an integral feature of many higher educational systems, including Canada's. Its scope has expanded massively and rapidly in recent years, and as a result, research priorities in this emerging field must also adapt. While the needs and conditions in societies where the research is taking place are critical, true knowledge about pertinent factors is rarely readily available (Holmberg, 2005). *The Finest Blend* fills the gap by delving further into the research and practice of blended and online learning in Canadian higher education and introduces the reader to the complexities of transitioning into technology-mediated instructional designs and practices.

To set the stage for the rest of the book, Michael Power (in Chapter 1) provides a historical review of how the traditional way of university class delivery and pedagogic practice through voice and text-based methods that are largely used in distance learning have intersected with evolving media and technology. Power uses the pendulum swing as a metaphor to denote open universities' efforts to facilitate graduate-level best practices in online and hybrid learning in the wake of technology advances and shortcomings. In the second chapter, Jay Wilson reflects on his autoethnographic research of a faculty member mentorship program and proposes a systematic approach to assisting professors in using technology and demonstrating how to apply frameworks throughout course preparation. Employing design-based research (DBR), Jennifer Lock and her colleagues (Chapter 3) investigate the instructional design of online orientation and its impact on students' readiness for learning online. They stress the instructor's critical role in allowing intentionality and flexibility for students with any skill sets to begin their online learning journeys, the requirement for orientation programs to reflect the real academic online environment, and the program designs from student perspectives to establish the required supports for students to build the capacities essential for success in an online learning environment.

Jane Costello and her colleagues (Chapter 4) share the reflections of four senior instructional designers' self-study on relationships with content authors and their crucial roles in supporting faculty practice and enabling the integration of media and technology in the graduate online learning environment. Wendy Kraglund-Gauthier (Chapter 5) performed a study on instructional designers' support of faculty practice through participatory action research. She examines faculty members' transition in teaching techniques and pedagogical thinking as they move from face-to-face classrooms to an online environment that incorporates synchronous and asynchronous interaction. In Chapter 6, Sawsen Lakhal showcases research results of a scholarship of teaching inquiry into current practices of the blended synchronous delivery mode in Quebec, highlighting the use of voice and text methods and the benefits and challenges that faculty members and students have encountered.

Following a survey of socioeconomic factors influencing the use of open educational resources in modern blended online graduate programs and three related case studies, Kathy Snow (Chapter 7) sheds light on the efforts made and challenges faced by a publicly funded university in developing sustainable "open" education initiatives to make learning a social process and to foster a learning ecosystem that extends beyond the time and space constraints of typical university education. Maurice Taylor and his collaborators (Chapter 8), using a qualitative case study research design, explore the learning needs and preferences of professors and students in their current practices of blended graduate program learning. In addition, they showcase initial insights into the balance between text and voice in their graduate blended learning program. Chapter 9 presents the findings of a virtual ethnographic investigation by Gale Parchoma and her collaborators into synchronous and asynchronous instructional designs in a doctoral course, as well as student engagement and embodiment. The concluding chapter by Jennifer Lock and Michael Power summarizes the primary ideas, problems, and issues raised in the preceding chapters, as well as the practical implications and future research directions.

The edited collection's core strength lies in the eclectic positionality of the contributors. Twenty-two authors from diverse backgrounds in eight "dual mode" universities with English and French language delivery across Canada have contributed to this 375-page volume. They are well-known scholars and researchers in technology-enabled and blended online education. Besides the editors themselves (Gale Parchoma, Michael Power, and Jennifer Lock), who are prominent figures known for their scholarship of teaching and learning in Canadian higher education, the contributors are recognized specialists in instructional science and design in higher education. Furthermore, this book includes experiential material in practical examples that help the reader see the contributors' concerns in technology-enhanced innovation of contemporary university learning design. They showcase comprehensive exploration of how graduate learning practices have changed, looking at pan-Canadian views, and discuss the different lines of models and methodologies employed within graduate university contexts. What has come out of this book is also an insight into how text and voice are used in graduate education programs delivered in a hybrid or online format across Canada.

However, more elaboration at the beginning of the book about the voice- and text-based learning environments in the Canadian context could have helped novice readers from broader backgrounds to gain deeper comprehension about the (initial) situation in context. In addition, amidst several technology-enabled blended and online learning innovations and strategies highlighted in this book, only a few brief elaborations on the particular technologies employed or/and integrated are present.

Despite these concerns, the volume successfully confirms the importance of equitable instructional designs and pedagogical practices in the emerging educational transformation to open and borderless blended online learning environments. It provides perspectives from a wide range of blended online learning scholars and empirical and personal accounts in higher education. The book is a valuable resource to academics, scholars, postgraduate students, educators, policymakers, instructional design specialists, administrators, and other stakeholders interested in educational innovation in areas such as technology-mediated pedagogy, virtual-based research, and blended online learning experiences in postsecondary contexts.

Acknowledgements

The author acknowledges The Indonesia Endowment Funds for Education (LPDP) for their support in the publication of this book review.

References

Holmberg, B. (2005). *Theory and practice of distance education*. Routledge. https://doi.org/10.4324/9780203973820

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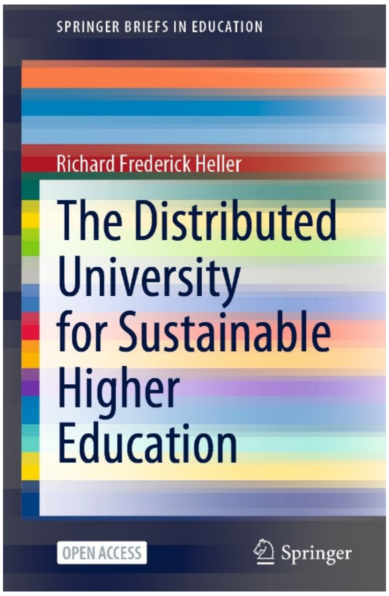
Book Review: The Distributed University for Sustainable Higher Education



Author: Richard F. Heller (Springer, 2021, 89 pages) ISBN: 978-981-16-6505-9 (paperback), ISBN: 978-981-16-6506-6 (e-book). https://doi.org/10.1007/978-981-16-6506-6

Reviewed by: Dr Upasana G. Singh, *University of KwaZulu-Natal, South Africa*, singhup@ukzn.ac.za

Keywords: book review, online learning, sustainable universities

The author, Richard F. Heller, is an established academic with more than 50 years of experience internationally in the higher education sector. He commenced his academic career in the United States, traversing the United Kingdom and Australia thereafter. His key forte is his vast experience in multiple educational settings and contexts, ranging from small to large classes, and multiple delivery types including problem-based and online learning. In addition to his lecturing, he has held a number of senior leadership roles and is a prolific researcher, with over four hundred publications to his credit.

Since Heller's journey into academia commenced without any formal training in the educational context, his book *The Distributed University for Sustainable Higher Education* resonates for many academics who have transitioned from students to lecturers during their higher education journey. Heller's practical and evidence-based approach to sharing his learnings during his varied academic journey at a number of higher education institutions provides a realistic view of the proposed "distributed university."

Organisation/Structure

The book is structured into five sections. Heller commences with a narrative description of the progression of higher education from the "first to the fourth-generation universities." Thereafter, in a systematic approach, he outlines what he believes are the main challenges universities face in the current context. Section three proposes solutions that can be explored to minimise the impact of the potential problems outlined in section two. Section four address the burning issue of funding required for an institution to sustain itself. Finally, Heller brings together the content presented in sections one through four in a comprehensive case study.

The main attraction of this book is its accurate reflection of an academic's journey in higher education, especially one without any formal degree or diploma in education. The author's regular references made to the literature, to substantiate his claims, strengthen the book. Additionally, reference to actual examples during his own tenure, clearly illustrated in diagrams (e.g., Figure 2.1 on p. 8), provides the required evidence to support his conclusions.

Heller also highlights key issues that academics face with the watering down of incentives associated with good teaching practices. Since a large portion of government subsidy is obtained from research publications, many universities have adopted a more authoritarian management style that promotes competition between and within universities, increasing bullying associated with "managerialism." Building trust is key to overcoming this.

While Heller acknowledges that all countries provide funding for the university sector, the extent of this government support varies, as does the combination of public and private universities and the reliance on student fees, all of which impact the financial sustainability of an institution. Many countries have now demanded that a larger portion of university costs should be borne by the students to help governments save costs. The author outlines that competition between universities should encourage them to improve their courses in an attempt to improve the quality of their offerings. However, the current business models adopted by universities highlight how higher education uncritically adopted emerging societal trends without considering whether they were relevant. Collaboration, as opposed to competition, is needed, and to support this, Heller proposes a new Bloom's taxonomy to include collaboration (Figure 3.1 on p. 58).

Assessment of Significance to the Field of Distance Education Theory, Research, and/or Practice

While *The Distributed University for Sustainable Higher Education* may have been written pre-COVID-19 pandemic, the information presented is extremely relevant in the context of the pandemic. The author highlights that the main mode of a successful university in the future will be online learning. While he acknowledges that this does "not preclude face-to-face experiences, and there are some things which can only be taught in person" (p. 63), digital transformation to embrace the fourth industrial revolution is imperative if an institution wants to sustain itself. The book transitions from problems to solutions and then addresses budget aspects to be considered before presenting key points to consider for the future of higher education. This approach ensures that the author builds a logical argument for the disruptions in higher education. Acknowledging the limitations associated with implications of a greater reliance on technology, Heller stresses, however, that "young people use the online space for so many of their activities," and so failing to "fully realise this in an educational context is misguided in the extreme, and misses a wonderful opportunity" (p. 64). The book makes a meaningful contribution to the literature on online education, research, and best practices. It stands apart from other literature in the area through its practical approach to making online education an integral part of the university of the future while ensuring environmental sustainability.

Overall Impression

I would highly recommend this book to higher education management and decision makers, as the author's pragmatic approach weaves together integral components of the fourth-generation university, including highlighting the need for collaboration, embracing online learning, considering environmental sustainability, and embracing technology to minimise the challenges associated with inequalities in access, affordability, downgrading of teaching in reward systems, and managerialism.

He proposes three new programmes. The first is the "International Tertiare (International Degree) Programme" to "reduce unnecessary competition between universities, reduce opportunities for managerialism, enhance international collaboration and the internationalisation of education" (p. 60). The second is the "Global Online Learning Programme (Australia Online)," which relies on embracing online learning as its foundation and could result in

> a wide reach across geographies, gender, levels of income and employment; costs of travel and accommodation [...] avoided, and manpower [...] not depleted during education; environmental sustainability; no evidence that e-learning is less effective than face-to-face teaching; and access to a wide range of educational resources that are freely available on the web (Open Educational Resources), reducing costs of production. (pp. 74–75)

The third is "Plan E for Education," which "questions the rationale for educational resources, produced in whole or in part through government funding, playing into the competitive business model of the higher education" (p. 78). Thus, Plan E would have three potential delivery strands: "Students access materials through the university that has produced them as per current practice, individual students could access materials for their own learning, and third-party organisations can contextualise and deliver them in innovative ways" (p. 89). This would complement the move towards the "distributed university," which would allow the higher education sector to have a sustainable future (p. 80).

Though the lucid experiences outlined in this book are drawn largely from the health arena, the presentation of the concepts, linked to the literature, ensures its general applicability across the university sector.

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MOOCs as a Research Agenda: Changes Over Time

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Abstract

MOOCs (massive open online courses) have attracted considerable attention from researchers. Fueled by constant change and developments in educational technology, the trends of MOOCs have varied greatly over the years. To detect and visualize the developments and changes in MOOC research, 4,652 articles published between 2009 and 2021 were retrieved from Web of Science and Scopus with the aid of CiteSpace. This study sought to explore the number of publications, co-citation network, cluster analysis, timeline analysis, burstness analysis, and dual-map overlays based on co-citation relationships. The first finding was that the number of publications on MOOCs had increased consistently, and grew especially quickly between 2013 and 2015. Second, the main topic of the top 10 co-cited studies revolved around the problem of learner continuance. Third, blended programs, task-technology fit, and comparative analysis have emerged as popular subjects. Fourth, the development of MOOC research has followed distinct phases, with 2009 to 2012 the starting phase, 2013 to 2015 the high growth phase, 2016 to 2018 the plateau phase, and 2019 to 2021 another peak phase. Lastly, both cluster analysis and dual-map overlays provided empirical evidence of cross-disciplinary research. Our findings provided an in-depth and dynamic understanding of the development and evolution of MOOC research and also proposed novel ideas for future studies.

Keywords: MOOC research, CiteSpace, co-citation analysis, visualization

MOOCs as a Research Agenda: Changes Over Time

Around the world, the education system is changing with the rapid development of information and communication technologies (Hoy, 2014). Massive open online courses (MOOCs) are a product of the development of educational technology. Providers in the US (edX, Coursera, Udacity, Kahn Academy, Udemy), China (Icourse, XuetangX, Zhihuishu), UK (FutureLearn), Europe (Iversity, FUN), Korea (K-MOOC), Middle East (Rwaq, Edraak), and Australia (Open2study) have transformed and upgraded traditional education by providing a more flexible, equitable, and cost-efficient approach (Brahimi & Sarirete, 2015). The growth of MOOCs has attracted many researchers, and the MOOC approach continues to be a popular research topic.

Several studies have looked into the fundamental qualities of MOOCs such as the platforms, courses, students, and teachers. For example, the issue of MOOC design has been raised since curriculum quality, determined by course design, plays an important role in teaching (Jordens & Zepke, 2009). Based on their examination of the teaching environment and characteristics of online platforms, Guàrdia et al. (2013) presented some principles for the design of MOOCs. These principles focused on empowering learners, and encouraged them to develop learning plans, engage in collaborative work, and express diverse opinions, thereby having a profound effect on the design of MOOCs.

An interdisciplinary trend integrating MOOCs into other fields has continued to develop (Wahid et al., 2020). For example, Zhou (2016) raised concerns about students' acceptance in MOOCs, using psychological theories such as the theory of planned behavior (Ajzen, 1985) and self-determination theory (Ryan & Deci, 2000). The combination of public media and MOOCs is another field widely discussed by scholars (Bulfin et al., 2014; Rowan & Hartnett, 2019). For example, Kovanović et al. (2015) focused on the public discourse of MOOCs and retrieved major topics and themes from news reports; they found that the main topics discussed in the media have changed over the years. Interaction is also an important aspect of MOOC research. Past studies have examined interactions between teachers and students, among students, and between humans and computers (Sunar et al., 2016).

Systematic investigations of MOOCs have been fruitful. The first systematic review of MOOCs was by Liyanagunawardena et al. (2013). They retrieved the literature published from 2008 to 2012 and analyzed the development of MOOCs during that period. Similarly, Zheng et al. (2019) explored researchers' interests and the development of MOOCs from 2012 to 2018 by examining the network of citations and overlapping keywords. A more comprehensive review by Wahid et al. (2020) examined 3,118 studies extracted from WOS (Web of Science) and Scopus databases, and analyzed the papers' sources, titles, fields of study, and keywords. They also explored the co-authorship, co-citation, and co-keywords relationships with VOSviewer.

Our study differed from previous studies in several respects. First, with more papers published on MOOCs, our study contained more comprehensive data, showing a bigger picture of MOOCs as a global movement. Furthermore, in contrast to the static analysis of MOOCs research profiles only, our research put effort into tracking its development over time. Moreover, rather than understanding developments and emerging trends through keywords, our research focused on co-citation relationships, an effective way of identifying complex networks and studying their evolution (Callon et al., 1983). Exploring the dynamics of emerging trends, developments, innovation points, and topics of a particular knowledge domain in a given period has become essential to researchers in an ever-changing society (Chen & Liu, 2020). To delve deeply into the developments in MOOCs between 2009 and 2021, this study focused on the number of publications, co-citation network, cluster analysis, timelines (Chen, 2017), burstness (Chen et al., 2012), and dual-map overlays (Chen & Leydesdorff, 2014) based on co-citation relationships and using CiteSpace.

Data Collection and Research Methods

Data Collection

WOS and Scopus provided users with prompt access to information from various literature databases (Mongeon & Paul-Hus, 2016). They were also considered indispensable tools for bibliometric analysis (Meho & Yang, 2006). WOS contained more papers on natural sciences and engineering while Scopus provided more coverage of social sciences and humanities (Mongeon & Paul-Hus, 2016). Combining WOS and Scopus made it possible to obtain complete data. The data used in this study were retrieved on Oct 27, 2021 from WOS and Scopus using the following retrieval formula:

- Topic: Massive open online courses or massive open online course. Several articles with either keyword in their title, abstract, or keywords were obtained.

- Timespan: 2009 to 2021 in WOS and Scopus. The first paper on MOOC research (Chongfu et al., 2009) was published in 2009.

- Document types: Articles, review articles, and early access in Science WOS; conference papers and articles in Scopus.

- Language: English. Literature related to MOOCs has been written in many languages, but only papers written in English were collected in this study.

In the end, 4,256 articles were extracted from Scopus and 1,599 articles from WOS. Since there was some overlap between the two databases, CiteSpace was used to filter and reduce the duplication of the literature; 623 articles were discarded. Finally, 4,652 records, including 3,129 Scopus records and 1,523 WOS records, were used in the study.

Research Method

Scientometrics is a powerful method for analyzing bibliometric networks (Van Eck & Waltman, 2014). Among various scientometrics analysis software, CiteSpace can effectively extract citations data; thus, it has been widely used by researchers (Synnestvedt et al., 2005). Compared with other science mapping tools, CiteSpace was designed with strong functionalities to detect and interpret new developments and emerging trends from research disciplines through clear visualized network diagrams (Hou et al., 2018). Therefore, CiteSpace (5.8.R3) was selected for this study.

Results

Number of Publications

Table 1 presents the number of articles published on MOOC research from 2009 to 2021, including the total number of papers published each year and the yearly proportion of the total. There was a dramatic increase in MOOC research during this period. Since the data were acquired in October 2021, only a portion of that years' worth of data was examined. The first two papers related to MOOCs appeared in 2009, marking the beginning of MOOC research. From 2009 to 2012, only 20 papers related to MOOCs were published. Interestingly, the year 2013 witnessed a dramatic increase in MOOC research, with 114 papers recorded that year. The total number of papers spiked after 2014, reaching its peak with 768 papers published in 2020.

Table 1

Yearly Totals of MOOC Research Publications From 2009 to 2021

Year	Number of documents	Percentage of total
2009	2	0.0%
2011	10	0.2%
2012	8	0.2%
2013	114	2.5%
2014	258	5.5%
2015	463	10.0%
2016	491	10.6%
2017	537	11.5%
2018	699	15.0%
2019	714	15.3%
2020	768	16.5%
2021	589	12.7%
Total	4,652	100.0%

Co-Citation Network

Co-citation analysis has become the leading tool for empirically studying the structure of scientific communication (Gmür, 2003). Therefore, we first did a co-citation network analysis to find the structure of MOOC research, as shown in Table 2 and Figure 1.

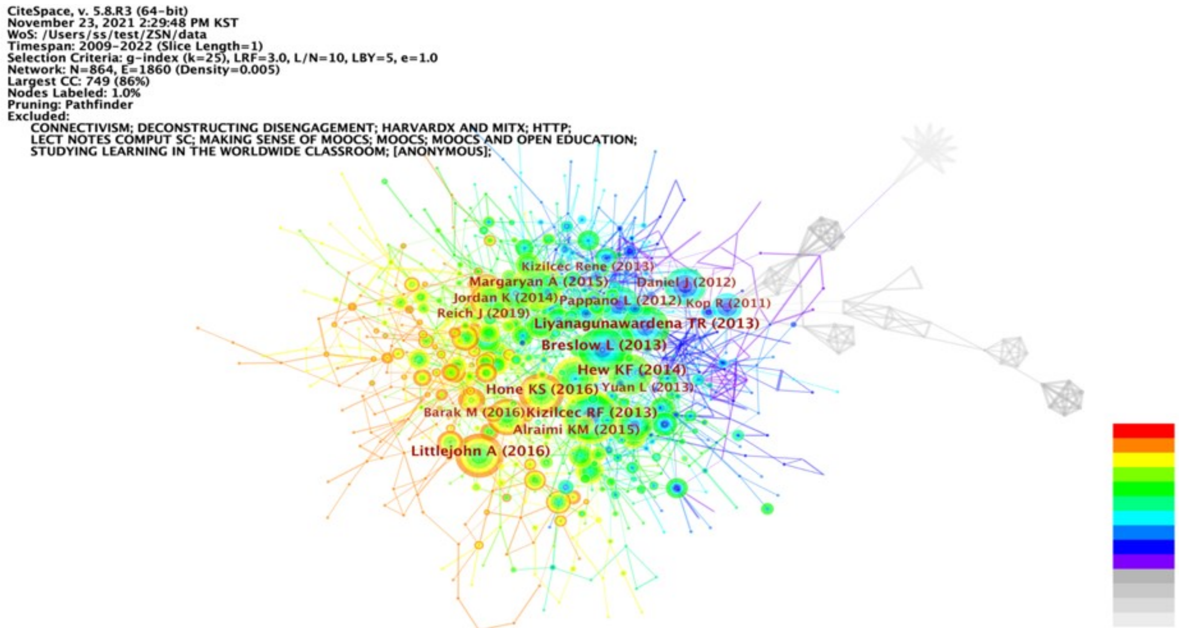
Table 2

Top 10 Co-Citation References

Frequency	Citation	Title
197	Liyanagunawardena et al. (2013)	MOOCs: A systematic study of the published literature 2008–2012
197	Breslow et al. (2013)	Studying learning in the worldwide classroom: Research into edX's first MOOC
172	Littlejohn et al. (2016)	Learning in MOOCs: Motivations and self-regulated learning in MOOCs
169	Hew & Cheung (2014)	Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges
153	Hone & El Said (2016)	Exploring the factors affecting MOOC retention: A survey study
151	Kizilcec et al. (2013)	Deconstructing disengagement: Analyzing learner subpopulations in massive open online courses
119	Alraimi et al. (2015)	Understanding the MOOCs continuance: The role of openness and reputation
117	Margaryan et al. (2015)	Instructional quality of massive open online courses (MOOCs)
111	Pappano (2012)	The year of the MOOC
107	Daniel (2012)	Making sense of MOOCs: Musings in a maze of myth, paradox and possibility

Figure 1

Network of Top 10 Co-Citation References (2009–2022)



We obtained 864 nodes and 1,860 links. Figure 2 shows the references whose co-citation count was beyond 70. We chose the 10 references cited most frequently as our research points (Table 2). It was clear that the bibliometrics that included the data from 2008 to 2012 (Liyanagunawardena et al., 2013) and the exploration of the first MOOC in edX (Breslow et al., 2013) tied for first place. The third (Littlejohn et al., 2016) and the fourth (Hew & Cheung, 2014) were related to the motivations of using MOOCs. Hone and El Said (2016), Kizilcec et al. (2013), and Alraimi et al. (2015) ranked fifth, sixth, and seventh respectively; all three explored the factors that influenced low MOOC completion rates. Instructional design quality was explored by Margaryan et al. (2015) and it was ranked eighth in frequency. Both of the last two, Pappano (2012) and Daniel (2012), described MOOCs in general; the former focused more on the attraction of MOOCs, while the latter shed objective light on dropout rates.

Cluster Analysis

The first step in exploring a knowledge domain is to identify highly cited documents using co-citation analysis; the second step is to analyze documents to determine the key research domain (Shi & Liu, 2019). In order to understand the topics of MOOC research, we conducted cluster analysis based on the co-citation network. The results are shown in Table 3 and Figure 2.

Table 3

Top 10 Clusters of the Co-Citation Network with Automatically Retrieved Labels

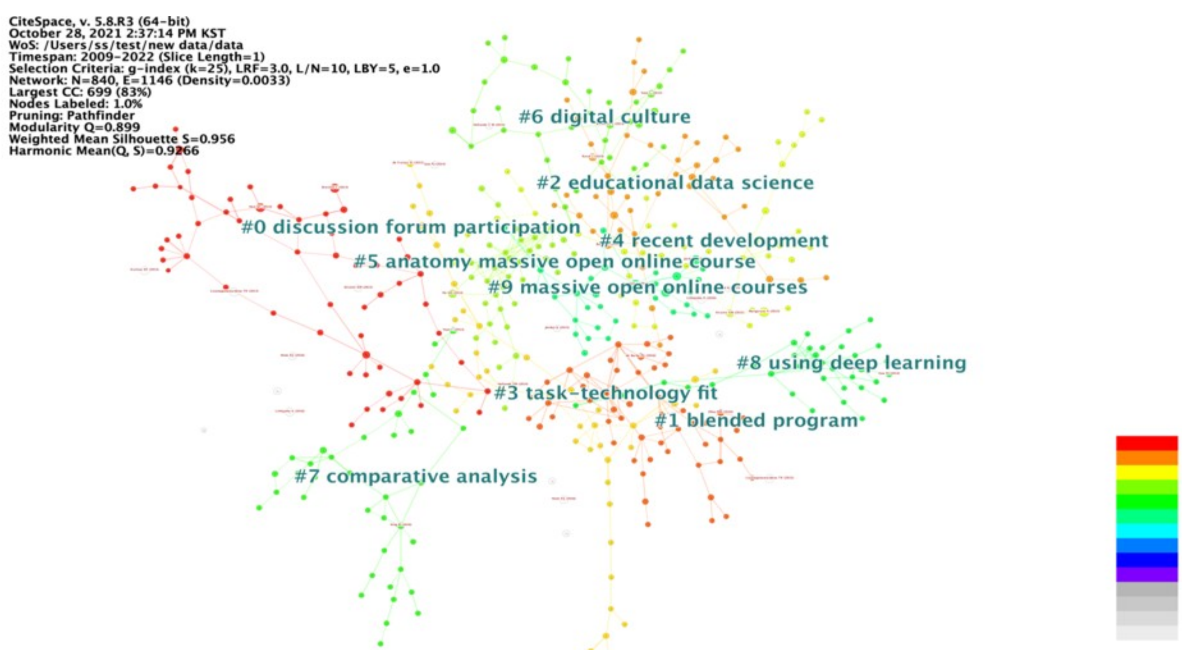
Cluster ID	Size	Mean(Year)	Label (LLR)
0	57	2013	discussion forum participation (357.11, 1.0E-4)
1	55	2016	blended program (178.67, 1.0E-4)
2	44	2014	educational data science (285.57, 1.0E-4)
3	44	2017	task-technology fit (308.02, 1.0E-4)
4	41	2014	recent development (341.84, 1.0E-4)
5	39	2013	anatomy massive open online course (346.89, 1.0E-4)
6	38	2012	digital culture (236.09, 1.0E-4)
7	37	2016	comparative analysis (190.7, 1.0E-4)
8	36	2014	using deep learning (129.7, 1.0E-4)
9	33	2012	massive open online courses (362.08, 1.0E-4)

Note: Mean (Year) represents the average number of years that papers associated with each cluster were published.

Figure 2 illustrates the network diagram of citation references with labels.

Figure 2

Top Nine Clusters Based on Co-Citation Network (2009–2021)



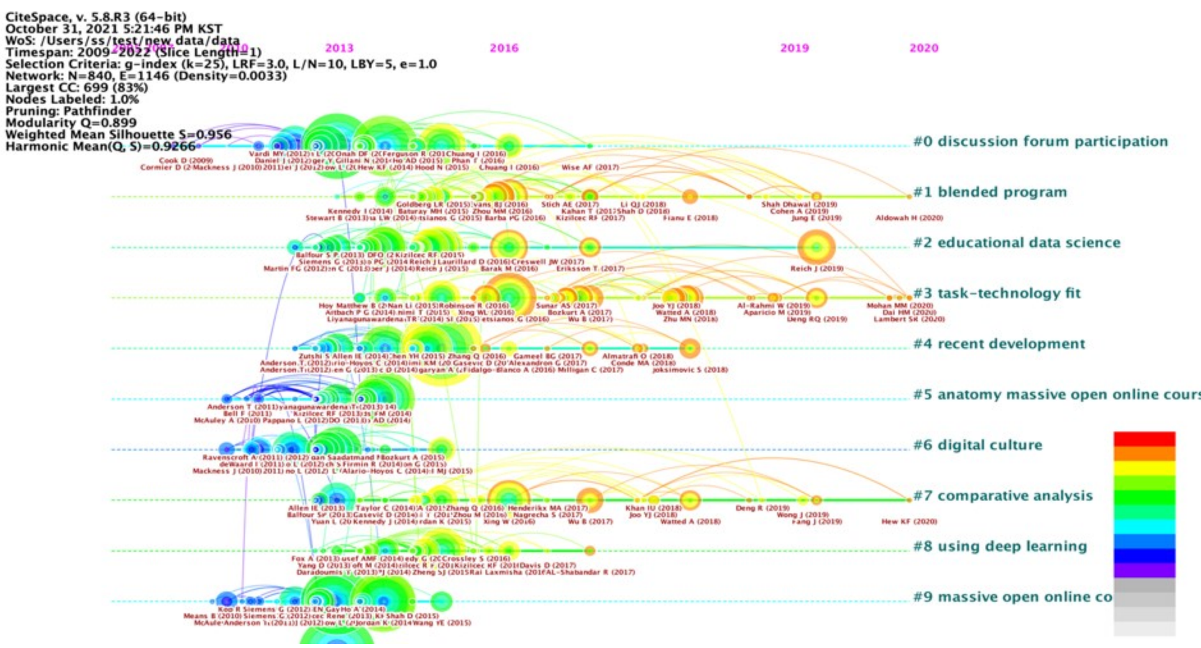
In total, 86 clusters, including 840 nodes and 1,146 links, were formed. We analyzed the largest 10 clusters in more detail (Table 3). In Figure 2, the 10 clusters are displayed in the network with corresponding numbers: #0 to #9 indicate different cluster sizes, with 0 representing the largest size and 9 representing the smallest. Accordingly, #0 discussion forum participation was the core topic in the MOOC research field, followed by #1 blended program. Then, #2 educational data science, attracted many scholars and ranked third. The fourth, called #3 task-technology fit, and #4 recent development, indicated that technical advancements made significant contributions to the development of MOOCs. Topics such as #5 anatomy massive open online course, #6 digital culture, and #7 comparative analysis represented emerging frontiers and hotspots in MOOC research, and ranked sixth, seventh, and eighth, respectively. Finally, #8 using deep learning was ranked ninth, followed by #9 massive open online courses.

Timeline Analysis

Timeline analysis displays the labels of clusters year by year, with appearance and disappearance times, thereby vividly showing dynamic changes (Chen, 2017). To reveal the gradual changes of MOOC research topics, we employed the year-by-year clustering function of CiteSpace to draw the timeline map based on co-citation relationships in Figure 3.

Figure 3

Timeline Map of the Top Nine Research Topics



Note: A higher resolution version is available.

Figure 3 focuses on the top nine clusters based on the co-citation network of MOOC research. According to the cluster duration, #0 discussion forum participation occupied the core position from 2009 to 2017; it was not only the favorite topic in the MOOC research field but also the earliest one. Although #5 anatomy massive open online course, #6 digital culture, and #9 massive open online courses, have interested scholars since 2010, their passions and enthusiasm did not last long, only four, five, and five years, respectively. Similarly, #8 using deep learning, spanned a short period, from 2013 to 2017. Since emerging in 2012, #4 recent development, maintained its presence until 2018. Apart from that, #2 educational data science, remained a notable research topic from 2012 to 2019. Compared to the clusters cited above, it is worth mentioning that #1 blended program, #3 task-technology fit, and #7 comparative analysis, have become the emerging frontiers in current MOOC research.

Burstness

Citation burstness is defined as an index indicating the frequency with which a particular reference is cited within different periods (Chen et al., 2012). Specifically, the higher the citation rate, the greater scholars' attention to the research topic. Detecting the burstness of literature has been regarded as an important way to explore the research frontier of a particular field in a specific period (Hou et al., 2018). In this study, we also employed the function of burstness in CiteSpace to explore the citation bursts of references (see Table 4).

Table 4

Top 20 References with the Strongest Citation Bursts

Citation	Strength	Begin year	End year	2009 to 2021
Kop (2011)	33.46	**2011**	2016	
Pappano (2012)	31.4	**2013**	2017	
Daniel (2012)	30.73	**2013**	2016	
Kolowich (2013)	12.06	**2013**	2016	
McAuley et al. (2010)	10.35	**2013**	2015	
Daniel (2012)	8.95	**2013**	2016	
Liyanagunawardena et al. (2013)	29.92	**2014**	2016	
Breslow et al. (2013)	21.8	**2014**	2018	
Yuan & Powell (2013)	17.62	**2014**	2017	
Kizilcec et al. (2013)	8.57	**2014**	2017	
McAuley et al. (2010)	8.54	**2014**	2015	
Yang et al. (2013)	8.83	**2015**	2017	
Hew & Cheung (2014)	18.08	**2017**	2019	
Kizilcec et al. (2013)	11.87	**2017**	2018	
Littlejohn et al. (2016)	22.48	**2019**	2022	
Barak et al. (2016)	13.34	**2019**	2022	
Kizilcec et al. (2017)	13.02	**2019**	2022	
Kaplan & Haenlein (2016)	12.71	**2019**	2022	
Alraimi et al. (2015)	11.6	**2019**	2020	

Note. The time interval on the timelines is blue; the red line segment depicts a burst's start and end.

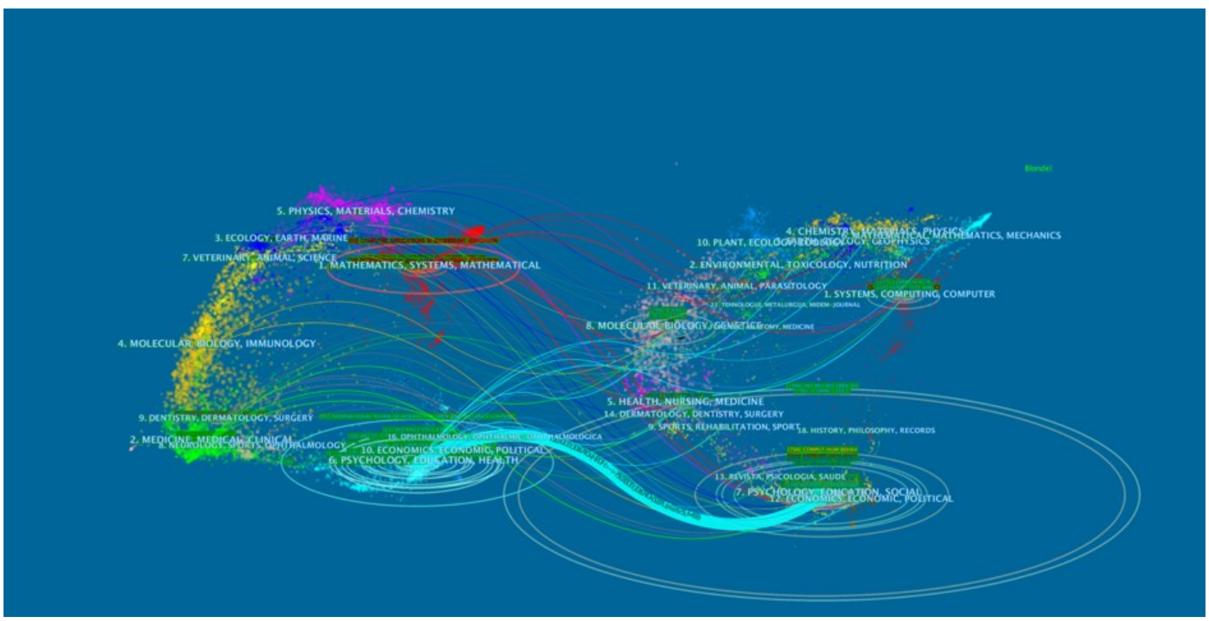
As a result, 243 burst items were found. We analyzed 20 references with the strongest citation bursts. Table 4 presents detailed information—first appearance, beginning year, ending year, strength, and timeline— for the top 20 citations from 2009 to 2021. In terms of the continuity of burst time, Kop (2011) was the citation with the longest burst time, lasting five years in total, followed by Pappano (2012) and Breslow et al. (2013), which each lasted four years. Furthermore, 11 of the 20 burst citations began predominantly in 2013 and 2014. In 2019 there were significant changes in the MOOC research field; five bursts emerged in this period, a development that warrants more attention as we continue to explore the MOOC research frontiers further. As for the periods where significant changes occurred, there were many bursts in 2013 to 2014. On the other hand, there were only slight changes in 2015 and 2018, while 2016 and 2018 were blank years, without any citations. Nevertheless, significant changes and research developments were achieved in 2019 to 2020.

Dual-Map Overlays

Dual-map overlays enabled us to complete several novel visual analytic tasks that were previously impossible to perform intuitively. By tracing the citation arcs with concentrated landing zones from the origin branch, it was simple to determine whether a set of publications integrated prior work from multiple disciplines (Chen & Leydesdorff, 2014). We drew the journal dual-map overlays, shown in Figure 4, to reveal the distribution of the knowledge base of MOOC research.

Figure 4

A Dual-Overlay Network of MOOC Research Based on JCR Journal Map (2009–2021)



Note: A higher resolution version is available.

Figure 4 maps the subject areas of MOOC research. Each node represents the research subject classified by CiteSpace, based on WOS and Scopus classifications. The left side depicts the base map of citing journals, while the right is the base map of cited journals. The colorful lines between the two maps represent the cited relationships of the target and source. As shown in Figure 4, more citing papers were published in the psychology, education, health area. Moreover, more cited papers were published in the psychology, education, social area. In addition, the subjects of mathematics, systems, mathematical gathered significant literature from citing journals and systems, computing, computer from cited journals.

Discussion

Number of Publications

Although the overall number of publications for 2021 was incomplete at the time of the study, the increase in yearly publications of MOOC research from 2009 to 2021 was clear. With more students engaged in MOOCs, more attention to them has come from government, educators, and commercial institutions (Yuan & Powell, 2013). The years 2013, 2014, and 2015 were noteworthy breakout years with a clear surge, probably driven by the promotion of MOOC platforms including edX, Coursera, and Udacity in the United States (Schuwer et al., 2015).

Co-Citation Analysis

As for the top 10 papers based on the co-citation analysis, in addition to some fundamental explanation of MOOCs, the focus of MOOC research has been more on students' continuance using MOOCs. Although Daniels (2012) first raised the problem of low completion rates in 2012, the lack of data prevented researchers from doing further studies at that time (Liyanagunawardena et al., 2013). With the publication of Breslow et al. (2013), significant progress was made, as their research was based on the data collected from *Circuits and Electronics (6.002x)*—the first MOOC developed by edX—and it explored students' learning situations and use of resources (Breslow et al., 2013). Later, studies on the issues of (a) motivation and self-regulated learning (Littlejohn et al., 2016); (b) students and instructors (Hew & Cheung, 2014); (c) retention of students (Hone & El Said, 2016); (d) learner subpopulations (Kizilcec et al., 2013); and (e) openness and reputation (Alraimi et al., 2015) tracked the problem of continued use of MOOCs.

Cluster Analysis

The result of cluster analysis showed the interdisciplinary nature of MOOC research. As seen from #3 task-technology fit, the task technology fit (TTF) model has been applied in educational studies since 2017 (Wu & Chen, 2017). It provided further evidence of interdisciplinary MOOC research since the TTF model was first introduced in the information science field (Lee et al., 2003). Furthermore, keywords like blended, data science, task-technology-fit, digital, and deep learning were further evidence of the interdisciplinary nature of MOOC research. Our findings were consistent with Veletsianos and Shepherdson (2015), and indicated that the scientific complexity of MOOC research was being addressed by researchers from diverse backgrounds. In particular, the interdisciplinary approach between education and computer science was revealed as the most remarkable.

Timeline Analysis

Timeline analysis revealed substantial changes in the topics of MOOC research, which means that researchers in each period had different interests. Despite that, #0 discussion forum participation, attracted scholars' interest early on and has been labeled the hottest research topic in the past. More recently, #1 blended program, #3 task-technology fit, and #7 comparative analysis have emerged as popular subjects. In terms of #1 blended program, MOOCs have often been viewed as an important supplement to traditional in-class learning (Zhang, 2016). Therefore, as of the 2020s, blended learning has become one of the key topics of interest for researchers.

Burstness Analysis

Burstness also changed year by year. By tracking the beginning year of burstness, it was easy to find some key turning points in the evolution of MOOCs. Before 2012, only one burstness occurred even though five papers had focused primarily on the concept, history, challenges, and trends of MOOCs (Liyanagunawardena et al., 2013). The years 2013 to 2015 were the period with the most rapid development of MOOCs, with 11 bursts appearing. Progress in MOOCs was relatively flat from 2016 to 2018, with only two bursts appearing. In contrast, 2019 was another peak period with five prominent points. Therefore, it was evident that 2009 to 2012 was the initial phase as MOOCs were being proposed, followed by the rapid development phase from 2013 to 2015. The period 2016 to 2018 was a relatively stable phase, with a new peak after 2019.

Dual-Map Overlays Analysis

Dual-map overlays analysis demonstrated that the MOOC research field has encompassed much cross-disciplinary knowledge. This is consistent with the result of cluster analysis, which also illustrated the strong cross-domain nature of MOOCs. The results of the dual-map overlay indicated that papers dealing with MOOCs appeared more often in journals related to education and society, in line with the original purpose of MOOCs, namely to realize UNESCO's goal of open and accessible education (Wahid et al., 2020). However, it is worth noting that both citing and cited journals represented almost all journal types. With the worldwide COVID-19 pandemic, open and massive video lectures from the world's best professors and the most reputable universities (Wu & Chen, 2017) in MOOCs have been regarded as an alternative way to offline classes, thus arousing the interest of many researchers from various perspectives (Bhattacharya et al., 2020).

Conclusion

This study conducted a bibliometric analysis of MOOC publications based on 4,652 items extracted from WOS and Scopus. By mapping the number of publications, co-citation network, clusters, timelines, burstness, and dual-map overlays of MOOC research, we concluded the following. First, the number of MOOC research publications has grown consistently, particularly between 2013 and 2015, with explosive growth. As for the top 10 co-citation articles, their main topics revolved around the problem of MOOC participation continuance. Among all the labels, #1 blended program, #3 task-technology fit, and #7 comparative analysis were the emerging and popular subjects. Regarding analysis of burstness, the development of MOOCs showed clear phases, with 2009 to 2012 the starting phase, 2013 to 2015 the high growth phase, 2016 to 2018 the plateau phase, and 2019 to 2021 another peak phase. Both cluster analysis and dual-map overlays provided empirical evidence of cross-disciplinary research. Collaboration between MOOCs and computer science was common in terms of research themes and journal distribution, in psychology, education, and health journals. Research about MOOCs also spans almost all types of journals.

Our study undertook a comprehensive overview of the systematic and objective analysis of MOOC research, contributing to a better understanding of the past and current research frontiers and interests in MOOC research and publications.

Limitations

CiteSpace is a professional scientometrics and data visualization tool. It enabled us to undertake structured and timeline analysis of contributions, developments, trends, and innovations, while considering authors, institutions, countries, and citations (Che et al., 2022). However, it is undeniable that CiteSpace has limitations. The type of data processed by CiteSpace is limited, which means that the literature selected by this study was not comprehensive because it lacked data available from Google Scholar and other similar services.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action control* (pp. 11–39). Springer. https://doi.org/10.1007/978-3-642-69746-3_2

Alraimi, K. M., Zo, H., & Ciganek, A. P. (2015). Understanding the MOOCs continuance: The role of openness and reputation. *Computers & Education*, *80*, 28–38. https://doi.org/10.1016/j.compedu.2014.08.006

Barak, M., Watted, A., & Haick, H. (2016). Motivation to learn in massive open online courses: Examining aspects of language and social engagement. *Computers & Education*, *94*, 49-60. https://doi.org/10.1016/j.compedu.2015.11.010

Bhattacharya, S., Singh, A., & Hossain, M. M. (2020). Health system strengthening through massive open online courses (MOOCs) during the COVID-19 pandemic: An analysis from the available evidence. *Journal of Education and Health Promotion*, *9*. https://doi.org/10.4103/jehp.jehp_377_20

Brahimi, T., & Sarirete, A. (2015). Learning outside the classroom through MOOCs. *Computers in Human Behavior*, *51*, 604–609. https://doi.org/10.1016/j.chb.2015.03.013

Breslow, L., Pritchard, D. E., DeBoer, J., Stump, G. S., Ho, A. D., & Seaton, D. T. (2013). Studying learning in the worldwide classroom: Research into edX's first MOOC. *Research & Practice in Assessment*, *8*, 13–25. https://eric.ed.gov/?id=ej1062850

Bulfin, S., Pangrazio, L., & Selwyn, N. (2014). Making 'MOOCs': The construction of a new digital higher education within news media discourse. *International Review of Research in Open and Distributed Learning*, *15*(5), 290–305. https://doi.org/10.19173/irrodl.v15i5.1856

Callon, M., Courtial, J.-P., Turner, W. A., & Bauin, S. (1983). From translations to problematic networks: An introduction to co-word analysis. *Social Science Information*, *22*(2), 191–235. https://doi.org/10.1177/053901883022002003

Che, S., Kamphuis, P., Zhang, S., Zhao, X., & Kim, J. H. (2022). A visualization analysis of crisis and risk communication research using Citespace. *International Journal of Environmental Research and Public Health*, *19*(5), 2923. https://doi.org/10.3390/ijerph19052923

Chen, C. (2017). Science mapping: A systematic review of the literature. *Journal of Data and Information Science*, *2*(2). https://doi.org/10.1515/jdis-2017-0006

Chen, C., Hu, Z., Liu, S., & Tseng, H. (2012). Emerging trends in regenerative medicine: A scientometric analysis in CiteSpace. *Expert Opinion on Biological Therapy*, *12*(5), 593–608. https://doi.org/10.1517/14712598.2012.674507

Chen, C., & Leydesdorff, L. (2014). Patterns of connections and movements in dual-map overlays: A new method of publication portfolio analysis. *Journal of the Association for Information Science and Technology*, *65*(2), 334–351. https://doi.org/10.1002/asi.22968

Chen, X., & Liu, Y. (2020). Visualization analysis of high-speed railway research based on CiteSpace. *Transport Policy*, *85*, 1–17. https://doi.org/10.1016/j.tranpol.2019.10.004

Chongfu, Z., Kun, Q., Yawei, W., Yin, H., & Heng, Z. (2009). *On experiment and analysis of MOOCS-based optical labels for optical packets switching*. 2009 2nd IEEE International Conference on Broadband Network & Multimedia Technology. https://doi.org/10.1109/icbnmt.2009.5348516

Daniel, J. (2012). Making sense of MOOCs: Musings in a maze of myth, paradox and possibility. *Journal of Interactive Media in Education*, *2012*(3). http://doi.org/10.5334/2012-18

Gmür, M. (2003). Co-citation analysis and the search for invisible colleges: A methodological evaluation. *Scientometrics*, *57*(1), 27–57. https://doi.org/10.1023/a:1023619503005

Guàrdia, L., Maina, M., & Sangrà, A. (2013). MOOC design principles: A pedagogical approach from the learner's perspective. *eLearning Papers* (33). https://r-libre.teluq.ca/596/

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review*, *12*, 45–58. https://doi.org/10.1016/j.edurev.2014.05.001

Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education*, *98*, 157–168. https://doi.org/10.1016/j.compedu.2016.03.016

Hou, J., Yang, X., & Chen, C. (2018). Emerging trends and new developments in information science: A document co-citation analysis (2009–2016). *Scientometrics*, *115*(2), 869–892. https://doi.org/10.1007/s11192-018-2695-9

Hoy, M. B. (2014). MOOCs 101: An introduction to massive open online courses. *Medical Reference Services Quarterly*, *33*(1), 85–91. https://doi.org/10.1080/02763869.2014.866490

Jordens, J. Z., & Zepke, N. (2009). A network approach to curriculum quality assessment. *Quality in Higher Education*, *15*(3), 279–289. https://doi.org/10.1080/13538320903399125

Kaplan, A. M., & Haenlein, M. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons*, *59*(4), 441-450. https://doi.org/10.1016/j.bushor.2016.03.008

Kizilcec, R. F., Pérez-Sanagustín, M., & Maldonado, J. J. (2017). Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses. *Computers & Education*, *104*, 18-33. https://doi.org/10.1016/j.compedu.2016.10.001

Kizilcec, R. F., Piech, C., & Schneider, E. (2013). Deconstructing disengagement: analyzing learner subpopulations in massive open online courses. *Proceedings of the Third International Conference on Learning Analytics and Knowledge*. https://doi.org/10.1145/2460296.2460330

Kolowich, S. (2013). The professors who make the MOOCs. *The Chronicle of Higher Education*, *18*, 1-12. https://urlzs.com/ZQDPM

Kop, R. (2011). The challenges to connectivist learning on open online networks: Learning experiences during a massive open online course. *International Review of Research in Open and Distributed Learning*, *12*(3), 19–38. https://doi.org/10.19173/irrodl.v12i3.882

Kovanović, V., Gašević, D., Joksimović, S., Hatala, M., & Adesope, O. (2015). Analytics of communities of inquiry: Effects of learning technology use on cognitive presence in asynchronous online discussions. *The Internet and Higher Education*, *27*, 74–89. https://doi.org/10.1016/j.iheduc.2015.06.002

Lee, Y., Kozar, K. A., & Larsen, K. R. (2003). The technology acceptance model: Past, present, and future. *Communications of the Association for Information Systems*, *12*(1), 50. https://doi.org/10.17705/1cais.01250

Littlejohn, A., Hood, N., Milligan, C., & Mustain, P. (2016). Learning in MOOCs: Motivations and self-regulated learning in MOOCs. *The Internet and Higher Education*, *29*, 40–48. https://doi.org/10.1016/j.iheduc.2015.12.003

Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008–2012. *International Review of Research in Open and Distributed Learning*, *14*(3), 202–227. https://doi.org/10.19173/irrodl.v14i3.1455

Margaryan, A., Bianco, M., & Littlejohn, A. (2015). Instructional quality of massive open online courses (MOOCs). *Computers & Education*, *80*, 77–83. https://doi.org/10.1016/j.compedu.2014.08.005

McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). The MOOC model for digital practice. https://urlzs.com/KMFcR

Meho, L. I., & Yang, K. (2006). A new era in citation and bibliometric analyses: Web of Science, Scopus, and Google Scholar. *arXiv preprint cs/0612132*. https://doi.org/10.1002/meet.14504301185

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Pappano, L. (2012). The year of the MOOC. *The New York Times*, *2*(12), 2012. https://www.lernspielwiese.com/cms/lib07/MN01909547/Centricity/Domain/272/The%20Year%20of%20the%20MOOC%20NY%20Times.pdf

Rowan, Y., & Hartnett, M. (2019). How have MOOCs been portrayed in the New Zealand public media? *Journal of Open, Flexible and Distance Learning*, *23*(2), 25–41. https://doi.org/10.1080/01587919.2019.1656153

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68. https://doi.org/10.1037/0003-066X.55.1.68

Schuwer, R., Gil-Jaurena, I., Aydin, C. H., Costello, E., Dalsgaard, C., Brown, M., Jansen, D., & Teixeira, A. (2015). Opportunities and threats of the MOOC movement for higher education: The European perspective. *International Review of Research in Open and Distributed Learning*, *16*(6), 20–38. https://doi.org/10.19173/irrodl.v16i6.2153

Shi, Y., & Liu, X. (2019). Research on the literature of green building based on the Web of Science: A scientometric analysis in CiteSpace (2002–2018). *Sustainability*, *11*(13), 3716. https://doi.org/10.3390/su11133716

Sunar, A. S., White, S., Abdullah, N. A., & Davis, H. C. (2016). How learners' interactions sustain engagement: A MOOC case study. *IEEE Transactions on Learning Technologies*, *10*(4), 475–487. https://doi.org/10.1109/tlt.2016.2633268

Synnestvedt, M. B., Chen, C., & Holmes, J. H. (2005). CiteSpace II: Visualization and knowledge discovery in bibliographic databases. *AMIA Annual Symposium Proceedings*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1560567/

Van Eck, N. J., & Waltman, L. (2014). Visualizing bibliometric networks. In Y. Ding, R. Rousseau & d. Wolfram (Eds.), *Measuring scholarly impact* (pp. 285–320). Springer. https://doi.org/10.1007/978-3-319-10377-8_13

Veletsianos, G., & Shepherdson, P. (2015). Who studies MOOCs? Interdisciplinarity in MOOC research and its changes over time. *International Review of Research in Open and Distributed Learning*, *16*(3), 1–17. https://doi.org/10.19173/irrodl.v16i3.2202

Wahid, R., Ahmi, A., & Alam, A. (2020). Growth and collaboration in massive open online courses: A bibliometric analysis. *International Review of Research in Open and Distributed Learning*, *21*(4), 292–322. https://doi.org/10.19173/irrodl.v21i4.4693

Wu, B., & Chen, X. (2017). Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. *Computers in Human Behavior*, *67*, 221–232. https://doi.org/10.1016/j.chb.2016.10.028

Yang, D., Sinha, T., Adamson, D., & Rosé, C. P. (2013). Turn on, tune in, drop out: Anticipating student dropouts in massive open online courses. Proceedings of the 2013 NIPS Data-driven education workshop. https://doi.org/10.7765/9781526102720.00010

Yuan, L., & Powell, S. (2013). *MOOCs and open education: Implications for higher education*. https://www.cetis.org.uk/

Zhang, J. (2016). Can MOOCs be interesting to students? An experimental investigation from regulatory focus perspective. *Computers & Education*, *95*, 340-351. https://doi.org/10.1016/j.compedu.2016.02.003

Zheng, X., Zhang, J., & Yang, X. (2019). *Visual analysis of MOOC research using Citespace from 2012 to 2018*. 2019 International Joint Conference on Information, Media and Engineering (IJCIME). https://doi.org/10.1109/ijcime49369.2019.00033

Zhou, M. (2016). Chinese university students' acceptance of MOOCs: A self-determination perspective. *Computers & Education*, *92*, 194–203. https://doi.org/10.1016/j.compedu.2015.10.012

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Using Low-immersive Virtual Reality in Online Learning: Field Notes from Environmental Management Education

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Abstract

Recent research in the field of virtual reality (VR) education is dominated by the application, experience, and effectiveness of high-immersive environments. However, high-immersive VR may not be accessible to all learners, with online distance learning students in particular unable to fully engage without being supplied with appropriate accessories. These field notes shed light on the role of low-immersive VR as a desktop tool for online distance learning students, exploring student experience of using 360° virtual spaces to undertake a summative assessment. Primary data collection in the form of an anonymous online survey was employed to gather feedback from postgraduate environmental management students who used low-immersive VR to undertake an environmental management system audit of a university campus. Quantitative results were analysed using descriptive statistics and qualitative responses using thematic analysis. Findings indicated that with guidance from the academic teaching staff and practice using the software, the majority of students felt both prepared and happy to undertake a summative assessment using VR spaces. Skills development and an appreciation of the effectiveness of the assessment approach were also highlighted as positive outcomes reinforcing findings from literature on the value of VR to improve learning outcomes particularly with practical tasks. Limitations of the assessment content and software were however noted by students, but both could be resolved with adaptations to the tool. It is hoped this research will be valuable to online education providers to demonstrate the value of using low-immersive VR within their programmes.

Keywords: virtual reality (VR), low-immersive, online learning, student experience, environmental management education

Introduction

The use of virtual reality (VR) technologies in education is increasing (Makransky & Petersen, 2019; Radianti et al., 2020), a growth which can be attributed to its value in enhancing both "learners' cognitive skills" and their learning outcomes (Merchant et al., 2014). Indeed, Taçgın (2020) emphasised the value of VR learning environments, highlighting their scope for enhanced outcomes when compared to traditional learning techniques, as well as the benefits they afford in both active participation and experimental learning. VR technologies create "realistic learning contexts" (Wu et al., 2020, p. 1991) that can be either high-immersive or low-immersive (sometimes referred to non-immersive or desktop). The difference between the two is the extent to which users feel the environment and thus "the concept of spatial presence" (Ventura et al., 2019, p. 2). High-immersive VR uses a head mounted display to facilitate engagement and presence through panoramic video technology, whereas participants are observers in low-immersive VR and use a device such as a computer to access the virtual space (Repetto et al., 2018; Ventura et al., 2019). There are conflicting results on whether high or low immersion technologies achieve better learning outcomes for users. Makransky et al. (2019) for instance found that whilst "students felt a greater sense of presence when they used the high immersion VR [...] they actually learned less compared to the low-immersion version of the simulation on a desktop computer" (p. 233), though Webster (2015) found that higher immersion technologies increased learning outcomes.

Literature indicates that a range of research has been undertaken on the use of VR in instructional design methods of education but with a specific focus on high-immersive environments (Pellas et al., 2021). Suh and Prophet (2018) also reported an increase in scholarly activity on immersive VR technologies. Makransky et al. (2019) emphasised that this enthusiasm and attention towards high-immersive VR could be attributed to a number of factors including continued investment in technologies, business analyses, and popular reports. Pellas et al. (2021) further accentuated that the widespread access to computing devices lends itself to the application of user-centered learning experiences. However, the application of high-immersive VR may not be accessible to all learners, with online distance students in particular unable to fully engage in this experience without being supplied with appropriate accessories. Indeed, whilst it should be noted that universities do provide students with access to the technology required to use more immersive VR environments, many accessories are only available to collect on loan from their respective libraries. Other options such as cardboard VR headsets do provide an affordable alternative to view more immersive content, however, they have limited interaction capabilities which Powell et al. (2016) reported was not "conducive to active exploration of a virtual space" (p. 5). These field notes will therefore develop current understanding of online student experiences of low-immersive VR, a desktop technology which could be valuable for students studying remotely who do not have direct access to the specialist and often expensive equipment required for high-immersive experiences and require more media interaction than that afforded by cardboard headsets.

VR can be used to make student learning more practice orientated (Radianti et al., 2020) and is particularly valuable within online learning as students can undertake "real life activities" within a virtual world (Huang & Liaw, 2018, p. 92). Wu et al., (2020) reinforced this value and specifically identified studies on environmental issues that included "higher-order competence development, require[d] the integration of multisensory channels and high intensity of interactions during learning" (p. 1992), which can be facilitated through VR. These field notes specifically explore online postgraduate environmental management students' experience using low-immersive VR within a summative assessment.

Methods

In these field notes, VR refers to the use of 360° panoramic photographs as a form of low-immersive media whereby online learners manoeuvre the room through their personal computer devices. These 360° rooms were hosted on the Seekbeak® platform. The content was created by both academic and learning media staff at the University of Derby, a mid-sized university in the United Kingdom. Seekbeak® was chosen as it allowed a significant amount of customisation, and images could be privately embedded into existing university webpages. Interactive elements such as text, videos, and images were simple to include, and it had the potential to be scaled up to use more widely across the university if required. From an educational perspective, Seekbeak® has accessibility features built in so that there were text options for students with either sight impairments who used screen readers, and for those who had very old equipment or poor connection speeds. Conversely, it was simple for students with modern mobile phones and even headsets to click a button and look around the space immersively, using their device's built-in gyroscope rather than a mouse or touchpad: the platform worked for all students.

This form of low-immersive VR was used within a summative assessment for an online postgraduate environmental management course. Student users navigated the 360° spaces to perform a virtual environmental management system (EMS) audit of a university campus site. An EMS is a structured system used to manage an organisation's environmental performance and responsibilities, and to minimise or control the impact of its activities on the environment. An EMS audit is used to investigate and evaluate the effectiveness of the EMS and the organisation's compliance with systems, policies, and regulations. Figures 1 and 2 are examples of the Seekbeak® virtual rooms which were created using the university buildings. Each room included a link to a site plan of the building as well as interactive elements called "hotspots" which, when clicked, provided further details and photographs of an aspect of the room such as inside a cupboard. The students navigated these virtual spaces to audit the university rooms and review compliance with the university's environmental policy, other internal commitments, such as carbon management plans, relevant legislation, and the requirements of EMS standards.

Figure 1

SeekBeak® 360° Room: Conference Room

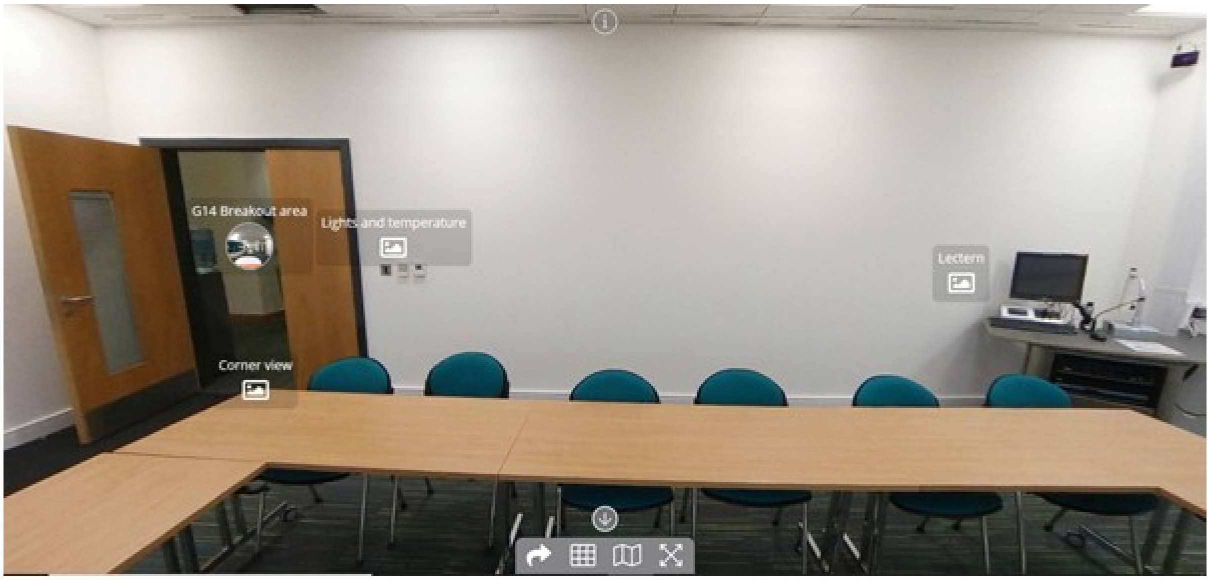
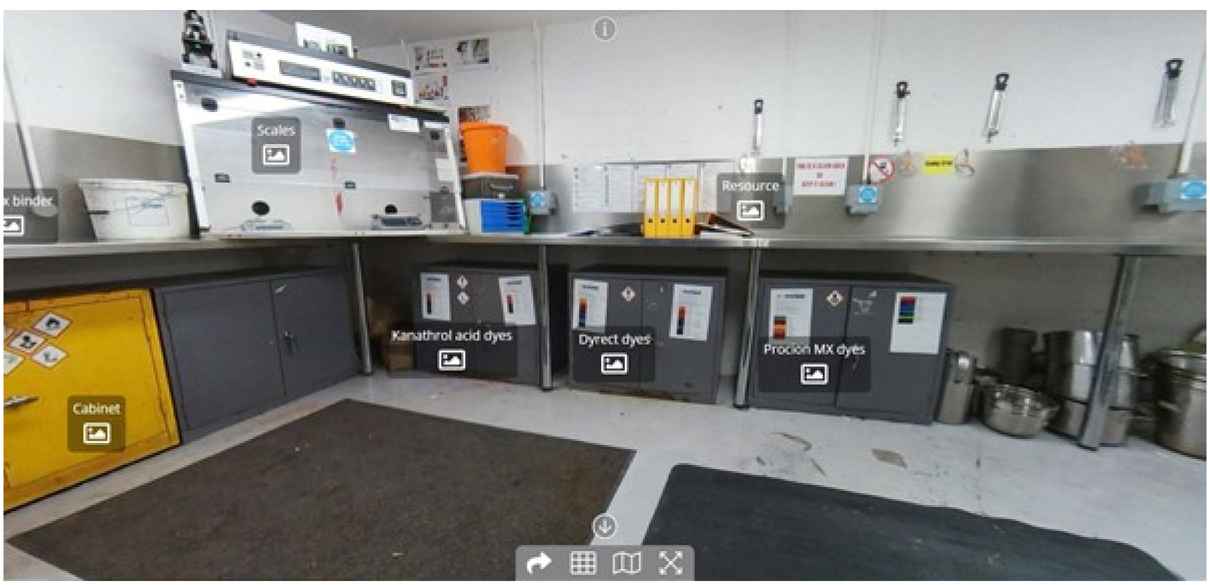


Figure 2

Seekbeak® 360° Room: Washroom in the Art and Design Department



Students were provided with guidance on how to use the Seekbeak® software prior to their EMS audit assessment. Practice versions of virtual rooms were available on the university Virtual Learning Environment to explore the tool, and students were encouraged to discuss their thoughts with their peers and the academic teaching staff both synchronously in live online drop-in sessions and asynchronously using online discussion boards. Students were also given the opportunity to speak to the university's environmental manager who undertakes the official EMS audit and to ask questions about the process and campus sites to help them complete their own audit assessment. This authentic and applied assessment was designed to allow students to develop key employability skills and apply their learning to a task they are likely to undertake in their prospective job roles (Villarroel et al., 2018). This is one of several applied and authentic assignments in the postgraduate environmental management programme within which this module sits, but it is the only assessment which includes VR. All students in the environmental management programme (n = 75) will complete this VR assessment as part of their core learning, but this module is also available to students of other programmes as an optional area of study. Further, it should be noted that students will also complete traditional assessment activities such as essays and reports within their studies to balance their workplace skills development with academic skills.

Data Collection and Analysis

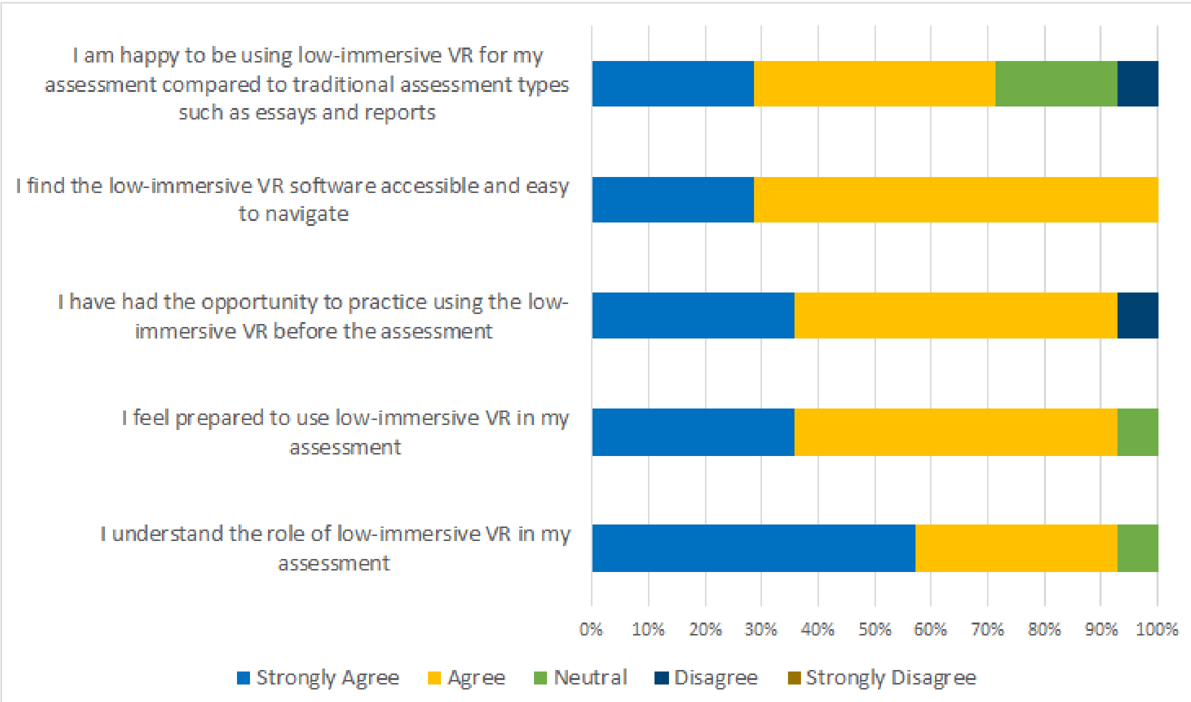
Participants for this study were recruited from among students studying a postgraduate environmental management online module which examined environmental assessment and management tools including EMS auditing. Primary data collection in the form of an anonymous online survey was employed to gather feedback from students whilst they undertook the summative audit assessment which included the use of low-immersive VR. The survey was hosted on Microsoft Forms, and the link to the survey was distributed during the module when students were completing the assessment. The survey link was open for students to complete for the remaining duration of the module (four weeks) until they submitted their summative assessment. The survey used a series of closed-ended questions with a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) to evaluate students' views of using low-immersive VR as well as a number of open-ended questions to allow expression of opinion. This approach was used by O'Connor et al. (2020) to assess student experience of 3D VR in radiography education. The quantitative results from the survey were analysed using descriptive statistics, and thematic analysis was used to analyse the qualitative responses. The lead author undertook the data analysis, and the results and themes were then discussed and reviewed by other members of the research team. The study was approved by the University of Derby Online Learning Ethics Committee.

Results

The survey was distributed to 42 level 7 postgraduate students and had a response rate of 33% (n = 14). Figure 3 highlights the quantitative outcomes of the survey.

Figure 3

Student Responses on Their Experiences Using the Low-Immersive VR



Results show 71% (n = 10) of the respondents agreed or strongly agreed that they were happy to be using the VR software in comparison to traditional academic assessments, and 100% of the students (n = 14) agreed or strongly agreed that they found the software easy to navigate. Whilst the majority of students (93%, n = 13) also agreed or strongly agreed that they felt prepared to use the software, understood its value in their assessment, and had the opportunity to practice, one student did not agree that they had had an opportunity to use the software prior to completing their summative assessment. This student however also reported that they strongly agreed they were prepared for the assessment, so their lack of practice time does not appear to have overly affected their wider view of the assessment. Another student also reported that they were not happy to be using the VR software in their assessment but had also either agreed or strongly agreed with the other statements shown in Figure 3 so, again, this did not adversely affect their preparation or understanding of the software.

Qualitative feedback from the survey has been collated into positive and negative views by theme as shown in tables 1 and 2.

Table 1

Positive Student Feedback

Theme	Example comment
New skills developed	"The experience is new to me, but it has been a good learning experience where I am able to adapt to a future trend in EMS audit assessment. I am able to find evidence of compliance by making certain observations I have been trained to check and analyse." "Excellent opportunity to test practical areas of environmental management and get used to industrial codes of practice such as standards, audits and very normal situations that we could work in." "It supports an understanding of the bigger picture and use of tools—without it I think it would be very hard to understand a standard because the documents are very dry and must be applied in a practical setting to gain full knowledge and understanding of what it means for an organisation together with the processes needed to improve environmental standards."
Value of the assessment approach	"It is an interesting way to assess rather than standard essays." "I am very grateful for the practice and the sessions that we got to support our understanding of the context of the coursework." "It is effective as a tool for assessment." "I think it is an excellent opportunity to test practical areas of environmental management and get used to industrial codes of practice such as standards, audits and very normal situations that we could work in."

Table 2

Negative Student Feedback

Theme	Example comment
Limitations of the customised content	"It is a useful tool generally but would be complemented by interviews and documents." "It would be beneficial if there were some notes provided with the low-immersive VR. Just to add those details that can't be told by VR alone, such as the lights in a room being on timers or not."
Limitations of the software	"Google maps provides a slightly more immersive and flexible experience than Seekbeak®."

Students reported positive outcomes to include the new skills they had developed from using the software as well as the effectiveness of the assessment style. Negative observations centred on the absence of additional documentation which would have been beneficial to complete the audit assessment, with one student noting, “It is effective as a tool for assessment but should be combined with other sources of information and more data as well.” Another student compared the tool to other software which they perceived to be of better quality. Further reported benefits of the low-immersive VR assessment tool were the “opportunity [it facilitated] to communicate with colleagues and get to know each other” and the skills developed that could be mentioned in job applications. One student reported, “It is something that can be used to sell above other candidates.” Students also valued the opportunity to practice using the software: “I found the VR quite easily accessible and after the [assessment] workshop, I had a much better understanding of what was required of me.”

Discussion

Recent research in the field of VR education is dominated by the application, experience, and effectiveness of high-immersive technology and whilst this is a valuable educational tool, it is not easily accessible to students studying online and at a distance from the university campus where the technology is typically located. These field notes therefore explore online student experiences with low-immersive VR which can be accessed remotely using desktop technology. The quantitative data collected highlights that the majority of students who participated in the survey reported a positive user experience. They were happy to use the low-immersive VR software, understood its role, had practised, and felt prepared when using the software and subsequently found it easy to use in their assessment.

Four key themes emerged from the qualitative data collected, and these were categorised as either positive or negative. Positive themes included the new skills developed and the perceived value of the assessment tool. This aligns with the benefits reported by Radianti et al. (2020), Wu et al. (2020), and Huang and Liaw (2018) who emphasised the value of undertaking realistic practice-orientated activities, such as an audit, in a virtual space. The student feedback on the effectiveness of the tool to support learning practical skills when compared to other assessment formats also aligned with the work of Taçgın (2020) and Merchant et al. (2014) who highlighted the potential of VR for enhancing learning outcomes and developing learner cognitive skills. A further interesting positive observation from the qualitative data was the student feedback that the VR assessment provided an opportunity for peer interaction, which took place during the practice discussions. This acknowledgement of an additional benefit beyond the aim of the assessment is particularly valuable given that online learning is generally undertaken independently and can therefore result in feelings of isolation. The negative themes from the qualitative data focused on the software used and the information included. These can be resolved by adding further material to the current content provided in the virtual spaces, thus facilitating an opportunity for the academic team to improve the task to develop the efficacy of the VR summative assessment. Specific actions include embedding further information into the virtual rooms via the “hotspots” tool, such as listing the chemicals stored in cupboards, outlining the local protocols for waste disposal, which can be room specific depending on the materials used, and providing links to the university environmental policy and internal plans and commitments. A limitation of virtual auditing is that assumptions can be made if there are insufficient facts and figures provided. This additional detail will therefore support students to complete a more comprehensive and informed EMS audit in future iterations of this assessment.

This specific EMS audit assessment and the corresponding content of the VR rooms was designed exclusively for one online module. However, the significant customisation benefits of the Seekbeak® platform have meant that the 360° panoramic photographs taken to develop this activity have been adapted for use in other programmes within the university but with different content included. For example, an office has been reimagined to explore occupational health and a kitchen used to demonstrate aspects of environmental health, thereby demonstrating the significant flexibility and value of Seekbeak® and the virtual spaces.

Limitations

Whilst these field notes offer valuable knowledge on student experience using low-immersive VR in online environmental management education, two limitations should be noted. Firstly, the response rate for the survey was lower than anticipated, an outcome which could have resulted from the research being undertaken by the academic staff teaching the module. This may have therefore affected the representativeness of student perceptions and experiences reported. Secondly, and comparable with the limitations noted by O'Connor (2020), who undertook a similar study, the student perceptions obtained via this research are subjective. Further research should therefore explore student views and competence with the tool alongside their assessment output to determine if students who valued the experience delivered high quality outputs. It would also be beneficial for an independent researcher to collect data from students for pedagogic scholarly activity rather than the academic teaching staff. That said, the results from this survey were generally positive, and these field notes have conveyed practical knowledge that may be helpful to other universities wishing to implement low-immersive VR for students studying online.

Conclusion

VR technologies are a valuable tool for education, allowing users to enhance their learning outcomes and develop cognitive skills. Whilst technology in high-immersive experiences increases and has a valuable place within higher education, it is important to consider how this type of learning tool can be accessed by online students to ensure they are afforded equivalent benefits. Low-immersive VR presents an opportunity for online learners to experience this real-world learning within a virtual space, and they can easily access it remotely on their own devices. This investigation into student experience using low-immersive VR has reinforced the value of the tool to online learners and highlighted their positive view of the technology when used in a summative assessment testing a practical skill. It is hoped this research will be valuable to online education providers to demonstrate the value of using low-immersive VR within their programmes.

References

Huang, H.-M., & Liaw, S.-S. (2018). An Analysis of learners' intentions toward virtual reality learning cased on constructivist and technology acceptance approaches. *The International Review of Research in Open and Distributed Learning*, 19(1). https://doi.org/10.19173/irrodl.v19i1.2503

Makransky, G., & Petersen, G. (2019). Investigating the process of learning with desktop virtual reality: A structural equation modelling approach. *Computers & Education*, *134*, 15–30, https://doi.org/10.1016/j.compedu.2019.02.002

Makransky, G., Terkildsen, T., & Mayer, R. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, *60*(1), 225–236. https://www.learntechlib.org/p/208141/

Merchant, Z., Goetz, E., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K–12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. http://dx.doi.org/10.1016/j.compedu.2013.07.033

O'Connor, M., Stowe, J., Potocnik, J., Giannotti, N., Murphy, S., & Rainford, L. (2020). 3D virtual reality simulation in radiography education: The students' experience. *Radiography*, *27*(1), 208–214. https://doi.org/10.1016/j.radi.2020.07.017

Pellas, N., Mystakidis, S., & Kazanidis, I. (2021). Immersive virtual reality in K–12 and higher education: A systematic review of the last decade scientific literature. *Virtual Reality*, *25*, 835–861. https://doi.org/10.1007/s10055-020-00489-9

Powell, W., Powell, V., Brown, P., Cook, M., & Uddin, J. (2016). Getting around in Google cardboard – exploring navigation preferences with low-cost mobile VR. In *IEEE 2nd workshop on everyday virtual reality (WEVR)* (pp. 5–8). IEEE. https://doi.org/10.1109/WEVR.2016.7859536

Radianti, J., Majchrzak, T., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, Article 103778. https://doi.org/10.1016/j.compedu.2019.103778

Repetto C., Germagnoli S., Triberti S., & Riva G. (2018). Learning into the wild: A protocol for the use of 360° video for foreign language learning. In P. Cipresso, S. Serino, Y. Ostrovsky, & J. Baker (Eds.), *International symposium on pervasive computing paradigms for mental health* (pp. 56–63). Springer. http://doi.org/10.1007/978-3-030-01093-5_8

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, *86*, 77–90. https://doi.org/10.1016/j.chb.2018.04.019

Taçgın, Z. (2020). The perceived effectiveness regarding immersive virtual reality learning environments changes by the prior knowledge of learners. *Education and Information Technologies, 25*, 2791–2809. https://doi.org/10.1007/s10639-019-10088-0

Ventura, S., Brivio, E., Riva, G., & Baños, R. M. (2019). Immersive versus non-immersive experience: Exploring the feasibility of memory assessment through 360° technology. *Frontiers in Psychology*, *10*, Article 2509. https://doi.org/10.3389/fpsyg.2019.02509

Villarroel, V., Bloxham, S., Bruna, D., Bruna, C., & Herrera-Seda, C. (2018). Authentic assessment: Creating a blueprint for course design. *Assessment & Evaluation in Higher Education*, *43*(5), 840–854. https://doi.org/10.1080/02602938.2017.1412396

Webster, R. (2015). Declarative knowledge acquisition in immersive virtual learning environments. *Interactive Learning Environments, 24*(6), 1319–1333. http://dx.doi.org/10.1080/10494820.2014.994533

Wu, B., Yu, X., & Gu, X. (2020). Effectiveness of immersive virtual reality using head-mounted displays on learning performance: A meta-analysis. *British Journal of Educational Technology, 51*(6), 1991–2005. https://doi.org/10.1111/bjet.13023